Geol Survey

Guide to the Geology of the Hardin Area

Calhoun and Greene Counties, Illinois

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Field Trip Guidebook 1994B May 21, 1994

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615 East Peabody Drive
Champaign, Illinois 61820-6964

Cover photo Looking south. Peoria Loess is exposed in the roadcut at Stop 4.

Geological Science Field Trips The Educational Extension Unit of the Illinois State Geological Survey (ISGS) conducts four free tours each year to acquaint the public with the geology, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each field trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers preparing earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students.

A brochure describing current year trips and a list of previous field trip guidebooks are available for planning class tours and private outings. These materials may be obtained by contacting the Educational Extension Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, Illinois 61820-6964. Telephone: (217) 333-4747.

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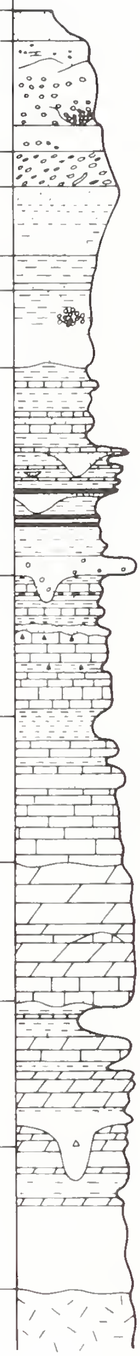
Printed by the authority of the State of Illinois/1994/500

CONTENTS

Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals	Quaternary 0–500'	Holocene	10,000	Recent—alluvium in river valleys
			Pleistocene Glacial Age	1.6 m.	Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, loess and sand dunes; covers nearly all of state except northwest corner and southern tip
		Tertiary 0–500'	Pliocene	5.3 m.	Chert gravel, present in northern, southern, and western Illinois
				36.6 m.	
			Eocene	57.8 m.	Mostly micaceous sand with some silt and clay, present only in southern Illinois
			Paleocene	66.4 m.	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0–300'		144 m.	Mostly sand, some thin beds of clay and, locally, gravel; present only in southern Illinois
				286 m.	
PALEOZOIC "Ancient Life"	Age of Amphibians and Early Plants	Pennsylvanian 0–3,000' ("Coal Measures")		320 m.	Largely shale and sandstone with beds of coal, limestone, and clay
		Mississippian 0–3,500'		360 m.	Black and gray shale at base; middle zone of thick limestone that grades to siltstone, chert, and shale; upper zone of interbedded sandstone, shale, and limestone
	Age of Fishes	Devonian 0–1,500'		408 m.	Thick limestone, minor sandstones and shales, largely chert and cherty limestone in southern Illinois; black shale at top
	Age of Invertebrates	Silurian 0–1,000'		438 m.	Principally dolomite and limestone
		Ordovician 500–2,000'		505 m.	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
		Cambrian 1,500–3,000'		570 m.	Chiefly sandstones with some dolomite and shale, exposed only in small areas in north-central Illinois
ARCHEOZOIC and PROTEROZOIC					Igneous and metamorphic rocks; known in Illinois only from deep wells



Generalized geologic column showing succession of rocks in Illinois.

HARDIN AREA

The *geology**, landscape, and mineral resources in Greene County and surrounding the town of Hardin in Calhoun County, Illinois, are subjects of this field trip. The area's rugged surface, one of the most scenic landscapes in the state, was formed mainly by differential erosion of Middle Mississippian and older *sedimentary strata* (see rock succession column on facing page) consisting of alternations of shale, sandstone, and *limestone*. The high ridges are remnants of an ancient *peneplain* underlain by resistant rocks. Small gently rolling upland tracts are mantled by wind-blown materials (loess, pronounced "luss") from deposits left by the melting of continental *glaciers* during the last 300,000 years. The area's surface continuity is broken where the loess and underlying *bedrock* were eroded by the Mississippi and Illinois Rivers and their tributaries. Some of the areas underlain by limestone show scattered *sinkholes*. The low areas consist of valleys or depressions underlain by relatively softer strata.

The town of Hardin is about 70 miles southwest of Springfield, some 248 miles southwest of Chicago, and approximately 45 miles north-northwest of St. Louis. Stone (limestone and dolomite) is the only mineral resource currently produced in Calhoun and Greene Counties.

Definitions Bedrock is a general term for solid rock that underlies soil or other unconsolidated, nonindurated, surface materials. The strata underlying Illinois are divided into *formations*. A formation is a consistent body of rocks with easily recognizable top and bottom boundaries; it must be readily traceable in the field and sufficiently widespread to be represented on a map. Many of the sedimentary formations have conformable contacts, which means that no significant interruptions in deposition took place between them. At some locations, although the composition and appearance of the rocks change significantly at the contact between two formations, the fossils in the rocks and the relationships between the rocks at the contact indicate that deposition was essentially continuous. At other contacts, the lower formation was subjected to weathering, and partial erosion occurred before the overlying formation was deposited. The fossils and other evidence in the formations may indicate a significant gap in time between deposition of the lower unit and the overlying unit. This type of contact is called an *unconformity*. The unconformity is called a *disconformity* if the *beds* above and below the unconformity are essentially parallel and an angular unconformity if the lower beds have been tilted and eroded before the overlying beds were deposited. Figure 1 shows several major unconformities (marked by a wavy line). Each unconformity represents a long interval of time during which (1) considerable rock, present in nearby regions, was eroded, or (2) deposition of the original sediment did not occur at this location. Several smaller unconformities are also present, representing shorter time intervals and thus smaller gaps in the depositional record.

Geologic History

Precambrian Era The area encompassed by Calhoun and Greene Counties, like the rest of Illinois, has undergone many changes through several billion years of geologic time. The oldest rocks beneath the field trip area belong to the ancient Precambrian (Archeozoic and Proterozoic) *basement complex*. We know relatively little about these rocks from direct observations because they are not exposed at the surface anywhere in Illinois. Only about 30 holes have been drilled deep enough in our state for geologists to collect samples from Precambrian rocks; depths range from 2,100 to 5,400 feet in northern Illinois and from 13,000 to more than 17,000 feet in southern Illinois. We know from these samples that the ancient rocks consist mostly of granitic and possibly *metamorphic*, crystalline rocks that formed about 1.5 to 1.0 billion years ago when molten igneous materials slowly solidified within the earth. By about 0.6 billion years ago, deep weathering

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* Words in italics are defined in the glossary at the back of the guidebook. Also please note: although Calhoun and Greene Counties, Illinois, and all present localities have only recently appeared within the geologic time frame, we use the present names of places and geologic features because they provide clear reference points for describing the ancient landscape.

CENOZOIC

System		Series	Stage	Substage	Formation	Graphic Column	Thickness (m)
Quaternary		Pleistocene	Holocene		Cahokia Alluvium		0-46
			Wisconsinan	Wood-fordian	Peoria Loess/Henry		0-23 0-15
				Farmdalian	Robein Silt		0-3
				Altonian	Roxana Silt		0-4
			Sangamonian				
			Illinoian		Loveland Silt/Pearl		0-30
					Glasford		
			Yarmouthian				
			Kansan		Banner		0-14
Tertiary		Pliocene			Grover Gravel		0-9

PALEOZOIC

System	Megagroup	Series	Group	Subgroup	Formation	Graphic Column	Thickness (m)
Pennsylvanian		Desmoinesian	Kewanee		Carbondale		20-36
					Spoon		0-26
Mississippian	Mammoth Cave Limestone	Valmeyeran			Ste. Genevieve Ls.		0-9
					St. Louis Ls.		52-73
					Salem Ls.		16-24
					Warsaw Sh.		15-24
					Keokuk Ls.		18-21
					Burlington Ls.		43-61
					Fern Glen		0-9
					Meppen Ls.		0-6
		Kinderhookian			Chouteau Ls.		6-21
	Knobs		New Albany Sh.		Hannibal Sh.		3-21
					Horton Creek		0-8
					Louisiana Ls.		0-1
Devonian		Upper			Saverton Sh.		0-2
					Sylamore Ss.		0-0.1
	Hunton Ls.	Middle			Cedar Valley Ls. Hoing Ss. Mbr.		0-12
Silurian		Niagaran			Joliet		0-8
		Alexandrian			Kankakee		0-9
					Edgewood		3-15
Ordovician		Cincinnatian	Maquoketa Sh.				30-61
	Ottawa Ls.	Champlainian	Galena	Kimmswick			21-27
				Decorah			9
			Platteville	Plattin			30
			Ancell		Joachim Dol.		24
					St. Peter Ss.		46
	Knox Dol.	Canadian	Prairie du Chien		*Shakopee Dol.		3+

*Only upper part exposed

Figure 1 Generalized stratigraphic column for the field trip area.

and erosion had exposed the ancient rocks at the surface, forming a landscape probably quite similar to part of the Missouri Ozarks. We have no rock record in Illinois for the long interval of weathering and erosion that lasted from the time Precambrian rocks were formed until Cambrian *sediments* were deposited across the older land surface. That interval is longer, however, than geologic time from the Cambrian to the present.

Geologists seldom see Precambrian rocks except as cuttings from drill holes, but they use various techniques to determine some of the characteristics of the basement complex. For example, surface mapping, measurements of Earth's gravitational and magnetic fields, and seismic records gathered for oil exploration and other research indicate that rift valleys, similar to those in east Africa, formed here in southernmost Illinois during the late Precambrian *Era*. This affected what later became the Kentucky–Illinois Fluorspar Mining District. In the midcontinent, these rift valleys are referred to as the Rough Creek *Graben* and the Reelfoot Rift (fig. 2). The midcontinental rift structures formed when plate *tectonic* movements (slow global deformation) began to rip apart an ancient Precambrian supercontinent that had formed earlier when various ancient landmasses came together. (Continental collision is going on today as the Indian subcontinent, moving northward against Asia, lifts and folds the Himalayas.) The slow fragmentation of the Precambrian supercontinent eventually isolated a new landmass, called *Laurasia*, which included much of what is now the North American continent.

Near the end of the Precambrian Era and continuing until Late Cambrian time about 570 million to 505 million years ago, tensional forces within the earth apparently caused block faulting and relatively rapid subsidence of the hilly landscape on a regional scale. This permitted the invasion of a shallow sea from the south and southwest.

Paleozoic Era Southern Illinois continued to sink slowly and accumulate sediments deposited in shallow seas that repeatedly covered the area. At least 15,000 feet of sedimentary strata accumulated during the 325 million years of the Paleozoic Era. These sediments, when compacted and hardened (*indurated*), and the underlying Precambrian rocks constitute the bedrock succession. Bedrock refers to the indurated rock units that underlie the soils or other relatively loose, crumbly, materials near Earth's surface.

In Calhoun and southwestern Greene Counties, the field trip area may be underlain by about 3,300 feet of Paleozoic sedimentary strata, ranging from deeply buried rocks of Late Cambrian age (about 523 million years old) to surface exposures of middle Mississippian age (about 358 million years old). From Middle Ordovician time about 460 million years ago until the end of the Permian *Period* (and the Paleozoic Era) about 245 million years ago, the area of Illinois, Indiana, and western Kentucky, sank more slowly than it did earlier. Repeatedly, sediments poured into a broad trough or embayment covering the area and spilled into surrounding areas as well. Because of compressive and stretching forces that developed at various times, Earth's thin crust has frequently been flexed and warped in various places. These recurrent movements during millions of years caused the seas to drain from the region and, later, to slowly return. Periodically, sea floors were uplifted and exposed to weathering and erosion by rain, wind, and streams. Because some strata were eroded, not all geologic units are represented in the rock record. Figure 1 shows the succession of rock strata a drill bit would penetrate in this area if the rock record were complete and all the formations were present (the oldest strata are at the lower right and the youngest are at the upper left).

Mesozoic and Cenozoic Eras After the Paleozoic Era, during the Mesozoic Era, the rise of the Pascola Arch (fig. 2) in southeastern Missouri and western Tennessee formed the Illinois Basin and separated it from other basins to the south. The Illinois Basin is a broad downwarp covering much of Illinois, southern Indiana, and western Kentucky (figs. 2, 3, and 4). Development of the Pascola Arch in conjunction with the earlier sinking of deeper parts of the area gave the Illinois

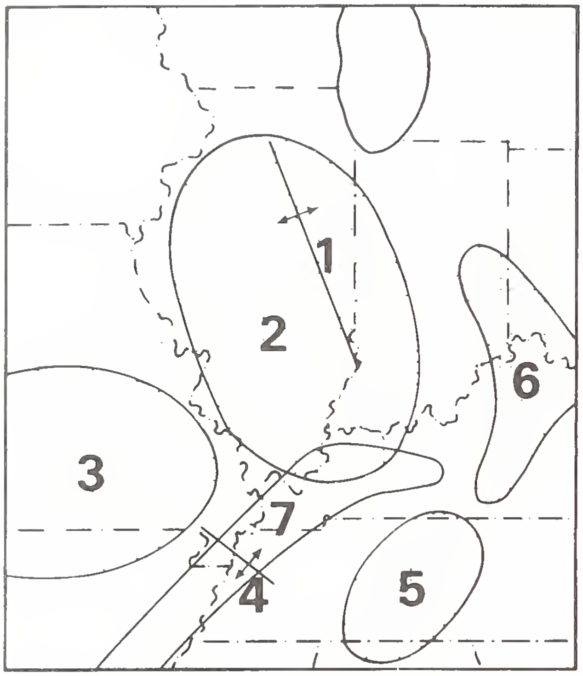

Figure 2 Location of some major structures in the Illinois region: (1) La Salle Anticlinorium, (2) Illinois Basin, (3) Ozark dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, and (7) Reelfoot Rift, southwest to northeast, and Rough Creek Graben, west to east.

Basin its present asymmetrical, spoon shape. The geologic map of Illinois (fig. 5) shows the distribution of various rock systems as they occur at the bedrock surface during different geologic time periods; that is, as if all glacial, windblown, and surface materials were removed.

The Hardin field trip area is located on the western flanks of the Illinois Basin. Bedrock strata here are tilted slightly to the east and south toward the deeper part of the basin located in Hamilton and White Counties some 160 miles away. Because tilting of the bedrock layers occurred several times during the Paleozoic Era, dips of successive strata are not always parallel to one another.

During the Mesozoic Era and part of the Cenozoic Era, a span of some 243 million years, and before the start of glaciation 1 to 2 millions years ago, the ancient Illinois land surface was exposed to long, intense weathering and erosion. From this erosion a *series* of deep valley systems were carved into the gently tilted bedrock formations. Later, the *topography* was flattened and filled in by the

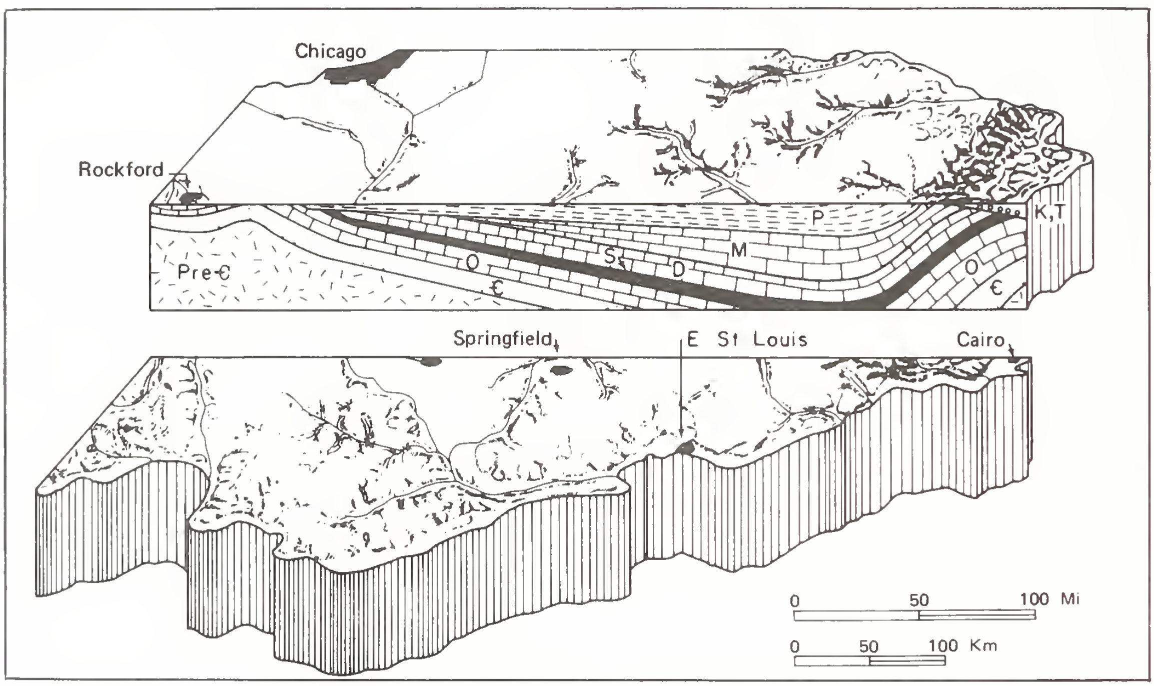

Figure 3 Stylized north–south cross sections shows the structure of the Illinois Basin. The thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-Є) granites that form a depression filled with layers of sedimentary rocks of various ages: Cambrian (Є), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). Scale is approximate.

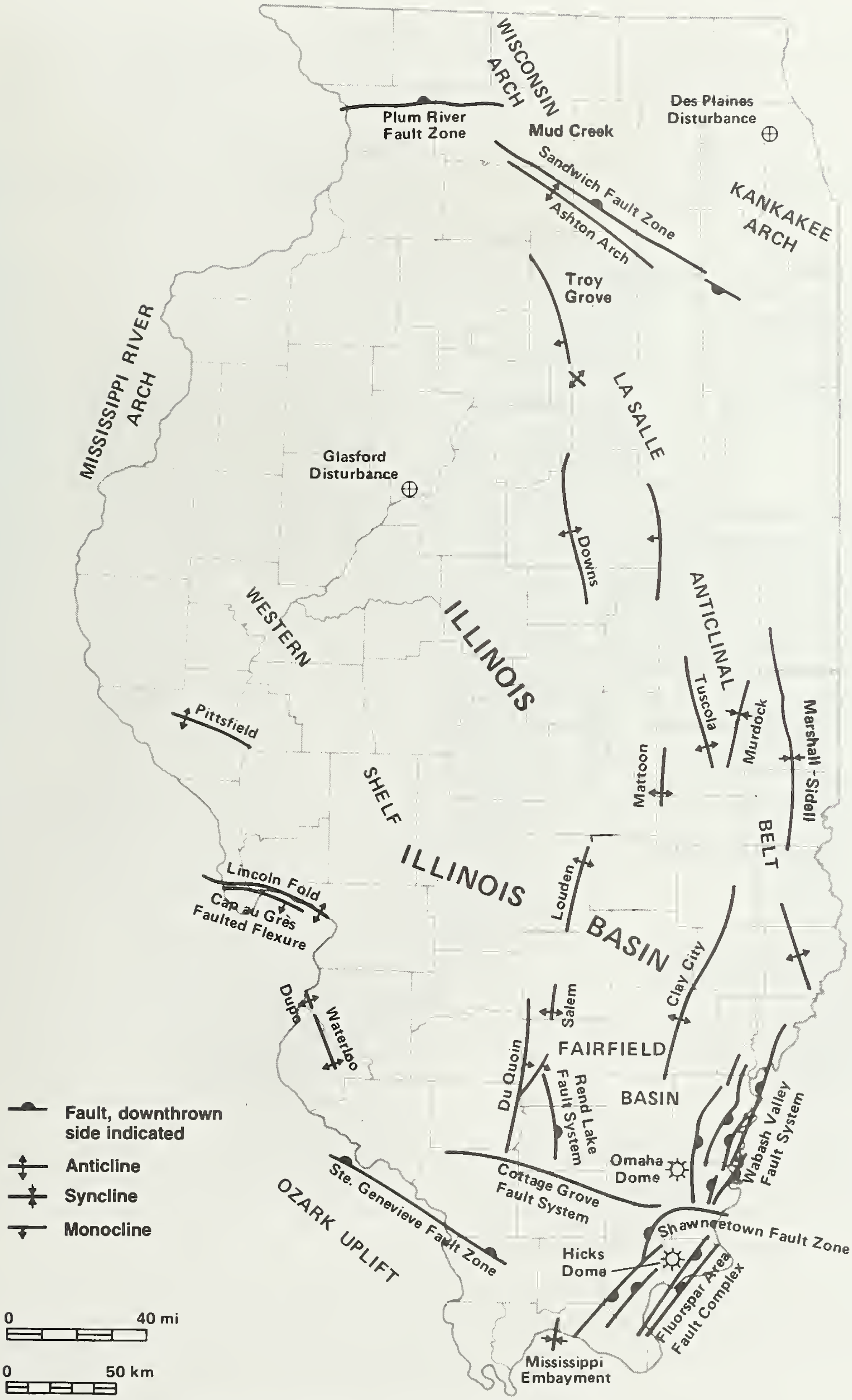

Figure 4 Structural features of Illinois (Treworgy 1981).

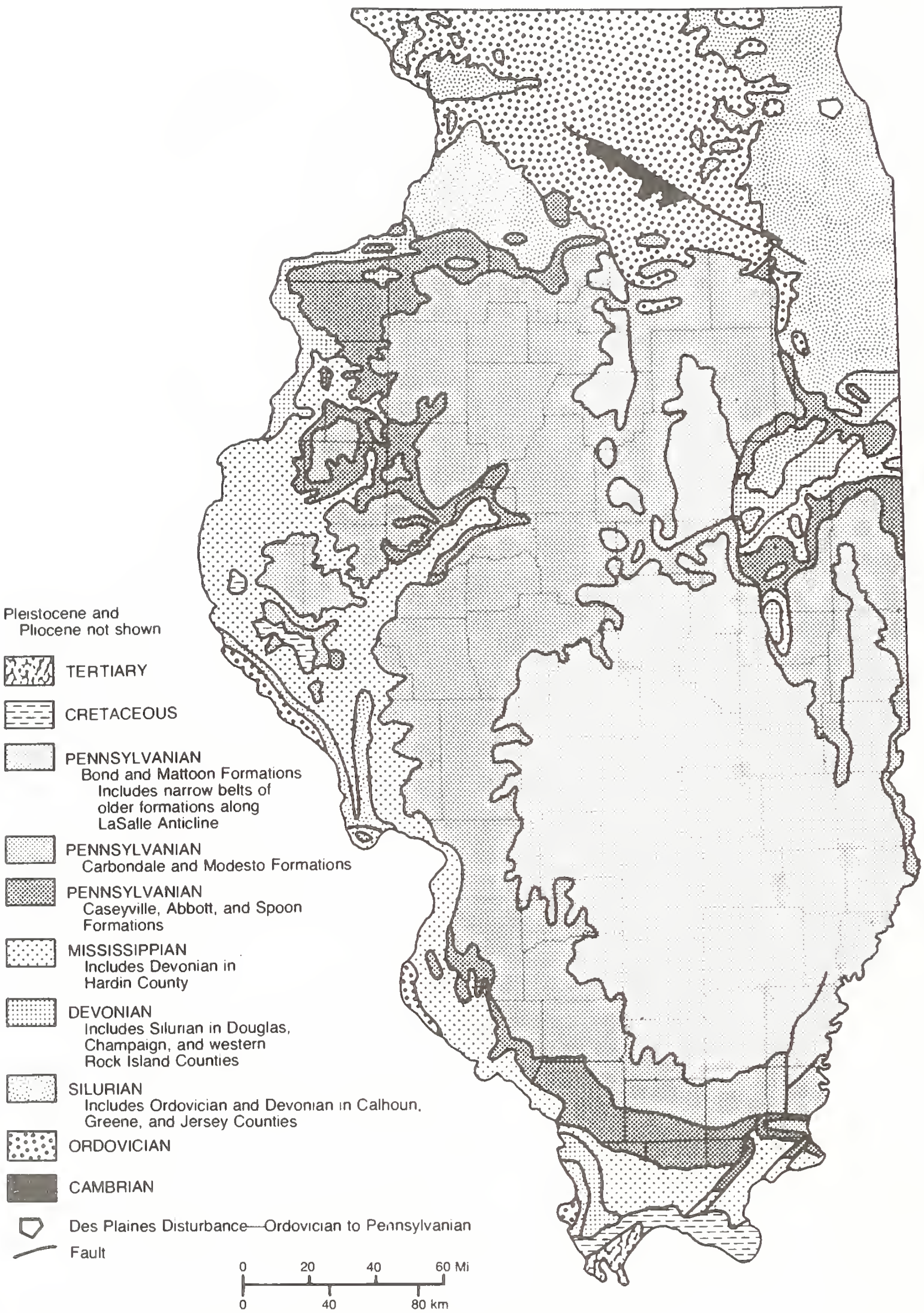

Figure 5 Bedrock geology beneath surficial deposits in Illinois.

repeated advance and melting back of the glaciers, which scoured and scraped the old erosion surface, affecting all bedrock except the Precambrian rocks. After the glaciers finally melted away, nonindurated deposits of *till* (sand, gravel, and silt) were left behind. Modern soils developed in these materials.

Glacial History A brief history of glaciation in North America and a description of the deposits commonly left by glaciers is found in *Pleistocene Glaciations in Illinois*, a section at the back of this guide booklet.

Beginning about 1.6 million years ago during the Pleistocene Epoch, massive ice sheets called continental glaciers, flowed slowly southward from centers of snow and ice accumulation in Canada. The last of these glaciers melted from northeastern Illinois about 13,500 years before the present (B.P.). Although ice sheets covered parts of Illinois several times during the Pleistocene Epoch, pre-Illinoian drift deposits are known only from the deeper parts of the largest bedrock valleys. During the Illinoian glaciation, around 270,000 years B.P., North American continental glaciers reached their southernmost extent, advancing as far south as the northern part of Johnson County, about 145 miles southeast of Hardin (fig. 6).

Until recently, glaciologists had assumed that ice thicknesses of 1 mile or more were reasonable for these glaciers. However, the ice may have only been about 2,000 feet thick in the Lake Michigan Basin and perhaps only 700 feet thick across much of the land surface (Clark et al. 1988). These conclusions are the result of studying, (1) the degree of consolidation and compaction of rock and soil materials that must have been under the ice, (2) comparisons between the inferred geometry and configuration of the ancient ice masses and those of present glaciers and ice caps, (3) comparisons between the mechanics of ice-flow observed in today's glaciers and ice caps and those inferred from detailed studies of the ancient glacial deposits, and (4) the amount of rebound of the Lake Michigan Basin, which had been depressed by the tremendous weight of the ice.

Although Illinoian glaciers probably formed morainic ridges similar to those of the later Wisconsinan glaciers, Illinoian moraines are not as prominent or apparently so numerous. In addition, Illinoian moraines have been exposed to weathering and erosion for thousands of years longer than their younger Wisconsinan counterparts. Scattered high hills in this part of Illinois have been attributed to morainal remnants.

As previously mentioned, erosion had carved an extensive network of bedrock valleys deep into the irregular bedrock surface by the time glaciation began about 1.6 million years ago. As glaciation began, however, the streams began to fill up with sediments because the flow or volume of water was insufficient to carry increasing loads of materials. During times of deglaciation vast quantities of meltwater and sediments were released from the waning ice front. No evidence indicates, however, that any pre-Illinoian fills in the preglacial valleys were ever completely flushed out of their channels by succeeding deglaciation meltwater torrents.

The topography of the bedrock surface through much of Illinois is largely covered by glacial deposits, except along the major streams and in areas mantled by thin drift near the glacial margins. This field trip is in an unglaciated area. The inferred glacial margin lies along the eastern part of the Illinois River floodplain.

A cover of Woodfordian windblown silt or loess covers the bedrock in Calhoun County and neighboring counties. These fine grained dust deposits are mostly of Wisconsinan age and about 40 feet thick near the rivers, but they thin-out across the uplands. The fertile soils in the field trip area have developed in the loess and the alluvial fill of the stream valleys.

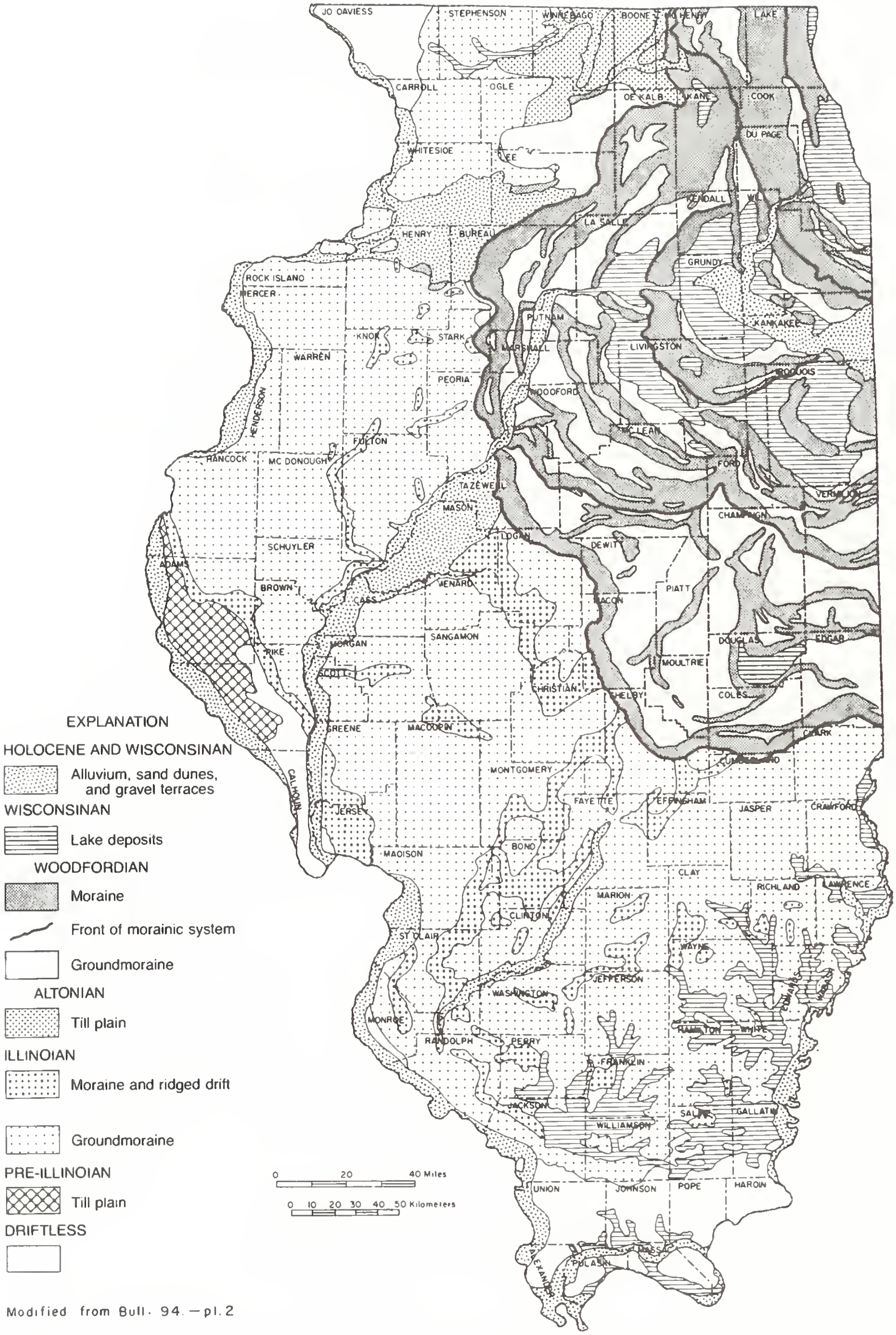

Figure 6 Generalized map of glacial deposits in Illinois (after Willman and Frye 1970).

Stratigraphy
The geologic column in figure 1 shows the succession of sedimentary rock strata, about 3,400 to 4,000 feet thick, that a drill bit might encounter in the field trip area. These bedrock strata range from about 490 million years old, the Ordovician Period, to about 355 million years old, the middle Mississippian (Valmeyeran) Period. The oldest rocks that you might see at the surface on this field trip are Ordovician in age. Younger strata of Silurian, Devonian, and Mississippian ages (fig. 1) underlie all or parts of Calhoun County and also occur at the surface in places. For more information, see the section, *Mississippian Deposition*, in the back of the guide booklet.

Structural Features
The north-south-trending landmass located between the Mississippi River to the west and the Illinois River to the east is named "Dividing Ridge." This isolated ridge is divided into three structural units: northern and southern units where the rocks dip gently northeastward, and an east–west structural unit that separates the northern and southern units. The east–west structural unit is made up of the Lincoln Anticline, the Cap au Grès Faulted Flexure, and the Troy–Brussels Syncline.

The Hardin field trip area is located along the western edge of the Illinois Basin in the northern structural unit. Regionally, the rocks dip northeastward at an average inclination of about 45 feet per mile. Locally, this regional dip is interrupted by many small northwest-southeast-trending anticlines and synclines. These structures include the Meppen Syncline, Otter Creek Syncline, Hardin Syncline, Gilead Anticline, and Nutwood Anticline.

This field trip will include a stop on the north-northwest flank of the northwest-southeast-trending Hardin Syncline. The Hardin Syncline is a structurally enclosed feature with 250 feet of negative relief in about 0.5 mile.

Physiographic Provinces A *physiographic province* is a region in which the *relief* and *landforms* differ markedly from those in adjacent regions. The Hardin field trip area is situated at the eastern edge of the Lincoln Hills Section of the Ozark Plateaus Province and the western boundary of the Till Plains Section of the Central Lowland Province (fig. 7). The present gross features of the Till Plains Section and the Ozark Plateaus are determined largely by their preglacial topography.

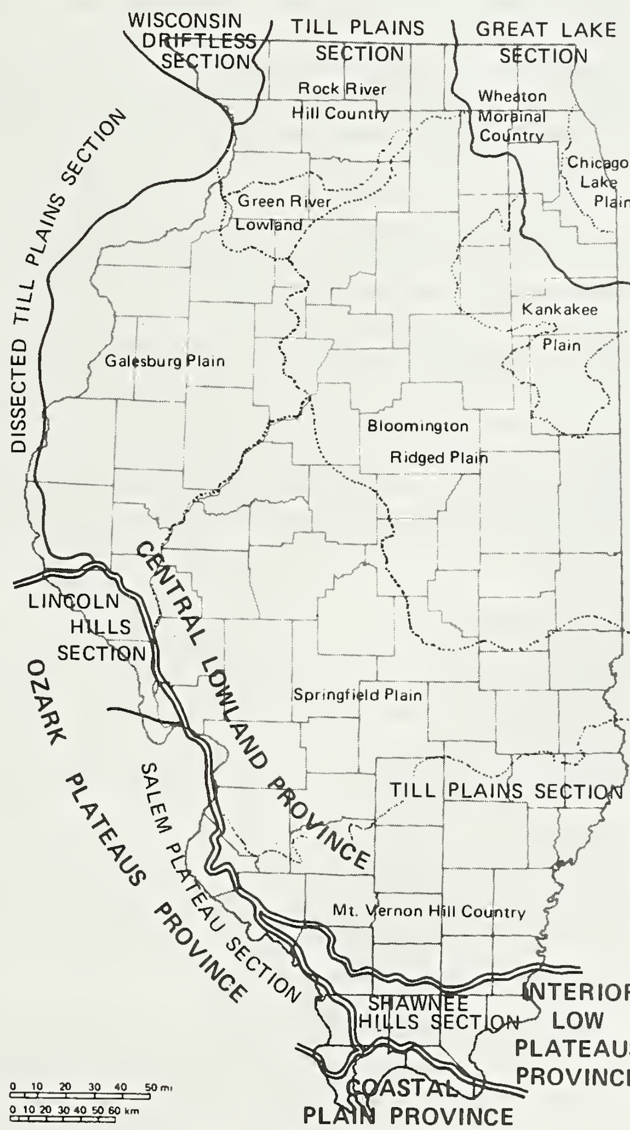

Figure 7 Physiographic divisions of Illinois.

The Hardin area lies on the eastern edge of the discontinuous older Ozark Plateau's upland, an extensive upland in southern Missouri and northern Arkansas. The eastern edge of this upland is buried beneath alluvial deposits in the Illinois River valley. The area includes the driftless and thinly drift-veneered cuestas (asymmetric ridges with a steep slope on one side and a gentle slope on the other) on pre-Pennsylvanian rocks that are structurally and topographically a part of the Ozark Dome.

The Lincoln Hills Section includes the partially drift-covered dissected plateau above the junction of the Mississippi and Illinois Rivers. The principal physiographic feature in Illinois is a maturely dissected central ridge that forms the watershed between the two major rivers throughout the length of the section. As noted, the eastern boundary follows the Illinoian drift border. The southern boundary with the Salem Plateau Section is drawn along the Cap au Grès flexure in the southern part of the county. In Illinois, the upland central ridge is largely underlain by Mississippian Valmeyeran limestones, of which the Burlington Limestone is most important physiographically; its boundaries coincide quite closely with the Mississippian–Pennsylvanian contact. The southern part is known as the Calhoun County Driftless Area, except it includes some loess deposits and a single high-channel filling of pre-Illinoian outwash gravel. Patchy remnants of pre-Illinoian drift are found in the northern part of the section. The plateau surface is rugged and broken by closely spaced valleys and ridges. Remnants of flat to gently rolling upland representing the Calhoun Peneplain are present along the ridge crest. The broad, deeply alluviated, terraced Mississippi and Illinois valleys have precipitous walls. Most of the minor valleys are narrow, V-shaped, and have steep gradients.

The Till Plains Section has seven divisions in Illinois, and we will encounter the Springfield Plain. The Springfield Plain on the eastern part of the field trip area includes the outer portion of the level area of the Illinoian glacial drift.

Relief The highest elevation on the field trip route is at the crest of Franklin Hill, slightly more than 800 feet mean sea level (msl). A short distance to the south along Dividing Ridge the elevation is 808 feet msl. The lowest elevation is approximately 419 feet msl, in the pool above the Melvin Price Locks and Dam No. 26 across the Mississippi River at Alton. The surface relief of the field trip route, calculated as the difference between the highest and lowest elevations, is about 389 feet. Local relief near the bluffs can be as much as 325 feet within less than 500 feet horizontally.

Mineral Resources

Mineral Production Among the 102 counties of Illinois, Calhoun County ranked 94th in 1990 for the total value of minerals extracted. Stone was the commodity extracted. Greene County ranked 85th among the states that extracted stone. The total production of stone is grouped with 14 other counties in District 4, where 28 companies have 33 operations. The total production of stone for this district was 11,953,000 tons valued at $43,851,000 (Samson 1992).

During 1990, the most recent year that complete records were published, 98 Illinois counties reported mineral production. The total value of all minerals extracted, processed, and manufactured in Illinois during 1991 was $2.9 billion. The total value reported to the U.S. Bureau of Mines (USBM) is not necessarily the actual value because many producers do not report their production figures.

During 1991, the value of extracted commodities in Illinois was $2,617.2 million, a decrease of 0.3% from 1990. Mineral fuels (coal, crude oil, and natural gas) made up 79.8% of the total value. Industrial and construction materials such as clay, fluorspar, sand and gravel, stone, and tripoli accounted for 19.9%. The remaining 0.3% came from metals such as lead, zinc, and silver, and from other minerals such as peat and gemstones (Samson 1991). Illinois ranked 17th among the

50 states in total production of nonfuel minerals and continued to lead all other states in production of industrial sand, tripoli, and fluorspar.

Groundwater Few of us think of *groundwater* as a mineral resource when we consider the natural resource potential of an area. Yet the availability of groundwater is essential for orderly economic and community development. More than 48% of the state's 11 million citizens depend on groundwater for their water supply.

The source of groundwater in Illinois is precipitation that infiltrates the soil and percolates downward into the groundwater system, which lies below the water table in the zone of saturation. Groundwater is stored in and transmitted through saturated earth materials called *aquifers.* An aquifer is a body of saturated earth materials of variable thickness that will yield sufficient water to serve as a water supply. Pores and other empty spaces in the earth materials of an aquifer must be permeable; that is, they must be large enough and interconnected so that water can overcome confining friction and move readily toward a point of discharge, such as a well, spring, or seep. Generally, the water-yielding capacity of an aquifer can be evaluated by constructing wells into it. The wells are then pumped to determine the quantity and quality of groundwater available for use.

Because geologic conditions differ from place to place, groundwater is readily available in some areas and extremely difficult to obtain in others. The variability of groundwater conditions in this area is shown in figure 8. Bergstrom and Zeizel (1957) reported that water-yielding sand and gravel deposits suitable for drilled wells are found mainly in the Mississippi and Illinois River valleys where deposits are 150 feet thick near the east river bank opposite Hardin. Sand is commonly encountered below 30 feet in the Illinois Valley, and coarse sand usually below 50 feet.

Many farm wells in Calhoun County obtain supplies of groundwater from fractures in the Keokuk–Burlington Limestone (fig. 8) in the northern quarter of the county. Farther south in the county the lower limestones are used for groundwater supplies. The limestones and dolomites are not extensively creviced, which limits the water supply for wells.

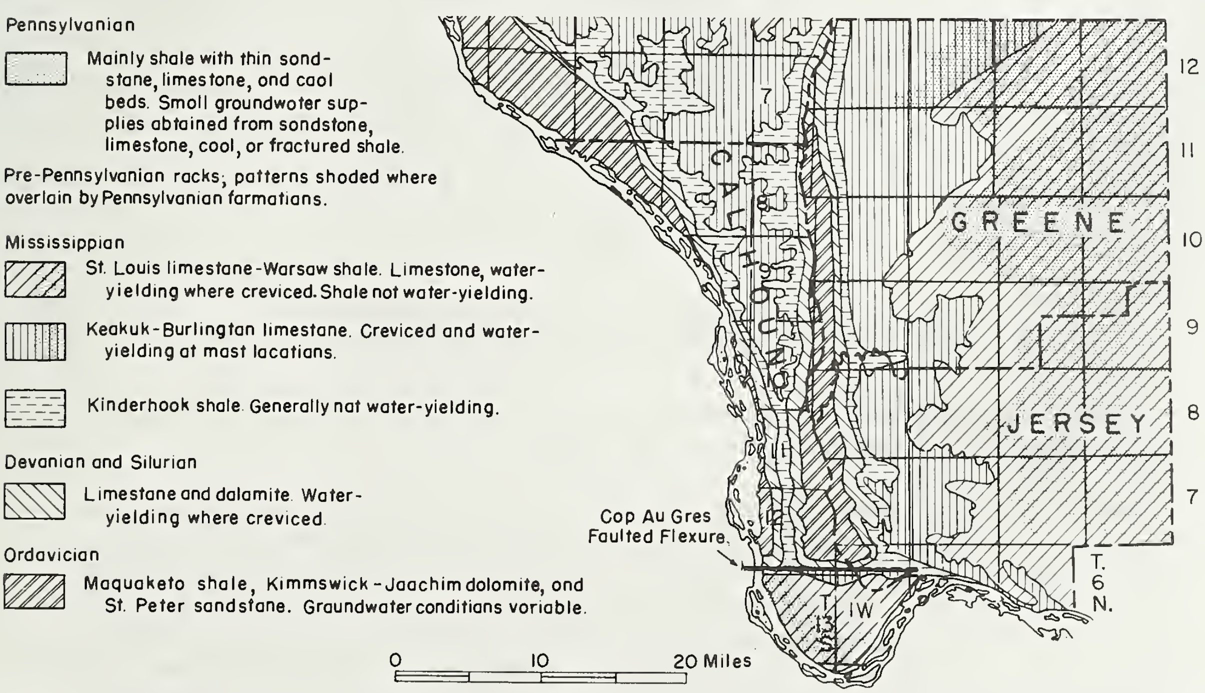

Figure 8 Areal distribution, type, and water-yielding character of upper bedrock formation (after Willman et al. 1967).

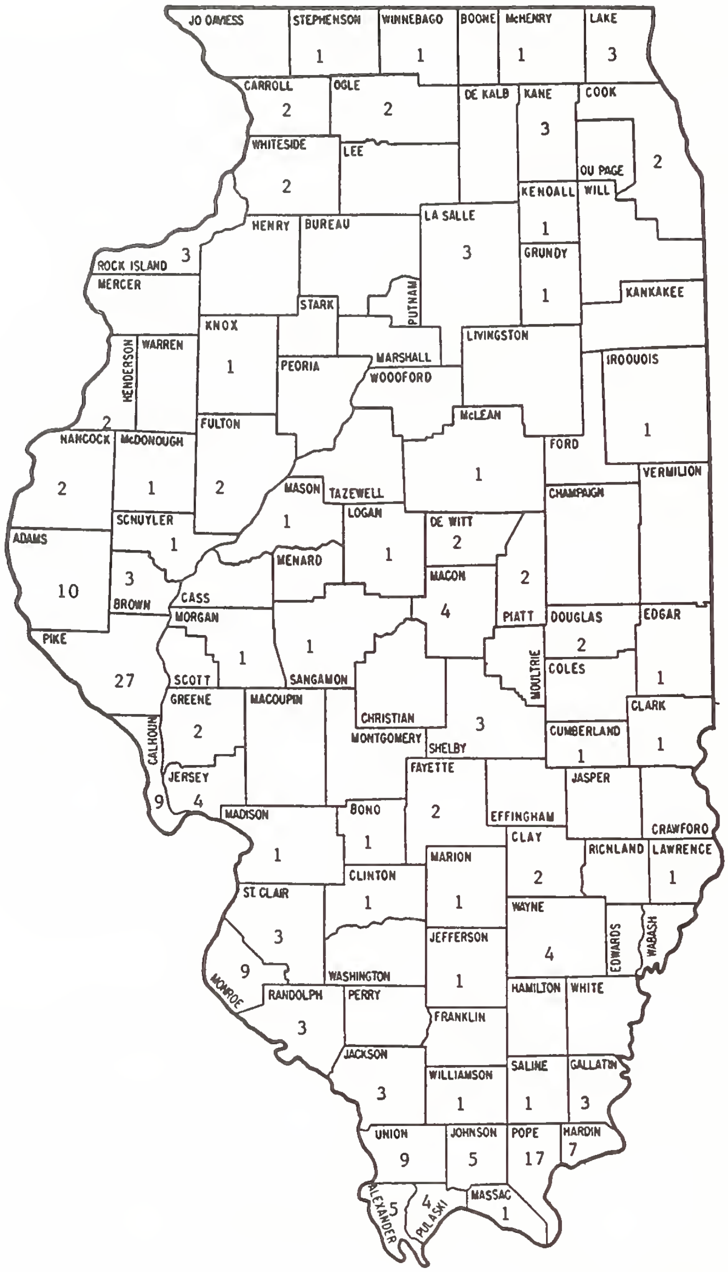

Figure 9 Number of springs in each county of Illinois. Note especially how many springs there are in Calhoun County.

The Burlington Limestone is the source of private groundwater supplies in most of the county, with wells less than 50 feet deep in some of the hollows.

Springs occur in all four physiographic provinces throughout Illinois (figs. 7 and 9). The boundary of each province is intimately related to the origin, structure, topography, lithology, and geologic age of the earth materials distributed throughout its area (Leighton 1948). Provincial areas are further divided into sections based on the physiography of various glacial and bedrock deposits (fig. 7). The Ozark Plateaus Province, bordering the Mississippi River in southwestern Illinois, is divided into the Lincoln Hills Section and the Salem Plateau Section. Water-bearing earth materials containing springs in these sections are found in eroded Ordovician, Silurian, Mississippian, and Pennsylvanian limestone, sandstone, and shale.

Water from Illinois springs discharges into two principal river basin regions, the Upper Mississippi Region or the Ohio River Region (Beck et al. 1988). The Upper Mississippi region includes about 80% of the state and the Illinois, Rock, Kaskaskia, and Big Muddy River Basins. Because of the varying responses of earth materials to erosion, the drainage basin regions are not coincident with the physiographic provinces in Illinois.

The supply of groundwater to springs varies seasonally with precipitation and from place to place, depending on the earth materials through which it flows. Variations in flow rate, water quality, and temperature are intimately related to land use and the lithologic type, distribution, and structural attitude of earth materials at a given spring. Distinctive relationships between the range and abundance of animals and plants can often be established through an inventory of species compared with analyses of earth materials sampled at spring openings and outflow channel sites.

In addition to providing a unique environment for studying the past and present distribution of aquatic biota, spring sites are important in settlement patterns of many regions where they served as local water supplies. Spring sites often contain evidence of human occupation in the form of pottery and metallic objects that are datable artifacts of historic and prehistoric culture. Many springs were regarded as sacred places and special sanctity was accorded to springs that served as the immediate sources of large streams and important rivers (Geikie 1912). Springs were important in Illinois and made evident at the many localities named for springs throughout the state; for example, Siloam Springs in Adams and Brown Counties, and Spring Bay in Woodford County.

Groundwater from bedrock is considerably more mineralized (salty) and not considered as important a source of water, as is the supply from unconsolidated deposits. Although it is not generally used, some of the moderately mineralized water from bedrock aquifers can be given to livestock when quality water is in short supply.

Information on the distribution of earth materials and the contained groundwater is constantly upgraded as new data are collected and compiled from drilling logs, test borings, and geophysical studies conducted by the Illinois State Geological Survey.

GUIDE TO THE ROUTE

Line up facing east on the south driveway of Calhoun High School. We'll start calculating mileage at the intersection of the south driveway and state route 100 (near center SE NW NW Section 23, T10S, R2W, 4th P.M., Calhoun County; Hardin 7.5-Minute Quadrangle [39090B5]*).

You must travel in the caravan. ***Do not drive ahead of the caravan!*** Please keep your headlights on while in the caravan. Drive safely but stay as close as you safely can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by an emergency vehicle with flashing lights and flags, then obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips, please do not litter or climb on fences. Leave all gates as you found them. These simple rules of courtesy also apply to public property. If you use this booklet for a field trip with your students, youth group, or family, you must get permission from property owners or their agents before entering private property.

STOP 1 *The Great Flood of 1993* will be one of several topics discussed at each stop along the field trip route, beginning here (near center, SE NW NW, Section 23, T10S, R2W, 4th P.M., Calhoun County; Hardin 7.5-Minute Quadrangle [39090B5]) and finishing up with Stop 10 at East Hardin.

From a human point of view, the 1993 flood was the most disastrous natural event in Illinois' history. The magnitude of this geologic event also captured the interest of geologists. The flooding presented opportunities to study firsthand the effects of geologic phenomena that we normally read about only in textbooks.

The 1993 flood was particularly unusual because (1) rivers remained above flood stage for months rather than days or weeks; (2) flooding, which is common in the spring, lasted through the summer; (3) most locations experienced several flood crests; and (4) flood crests set new highs for the historical record. Here at Hardin, the flood waters crested at a maximum of 15.5 feet above flood stage on July 20, 1993.

Dr. Terry F. Strauch, Superintendent of Calhoun Community Unit District 40, has kindly provided us with personal narratives that illustrate the human and logistical problems associated with flooding in the school district and throughout the region.

> Many adjustments had to be made to carry on the business of both the school district and the region in general during the flood. As you know, many communities in Illinois have snow routes, which go into effect when heavy snows blanket their regions. In Calhoun County, we have flood routes. But the flooding was so great in the summer of 1993 that not only were state highway routes flooded, so were the flood routes. Busing students to school became impossible. Teachers were boated across the river by the Illinois Department of Transportation. Prospective teachers could not get into the area for interviews, so Unit 100 in Jerseyville, about 20 miles east of here, provided their offices for us to interview teachers. Also, supplies were shipped into Unit 100, where we picked them up.

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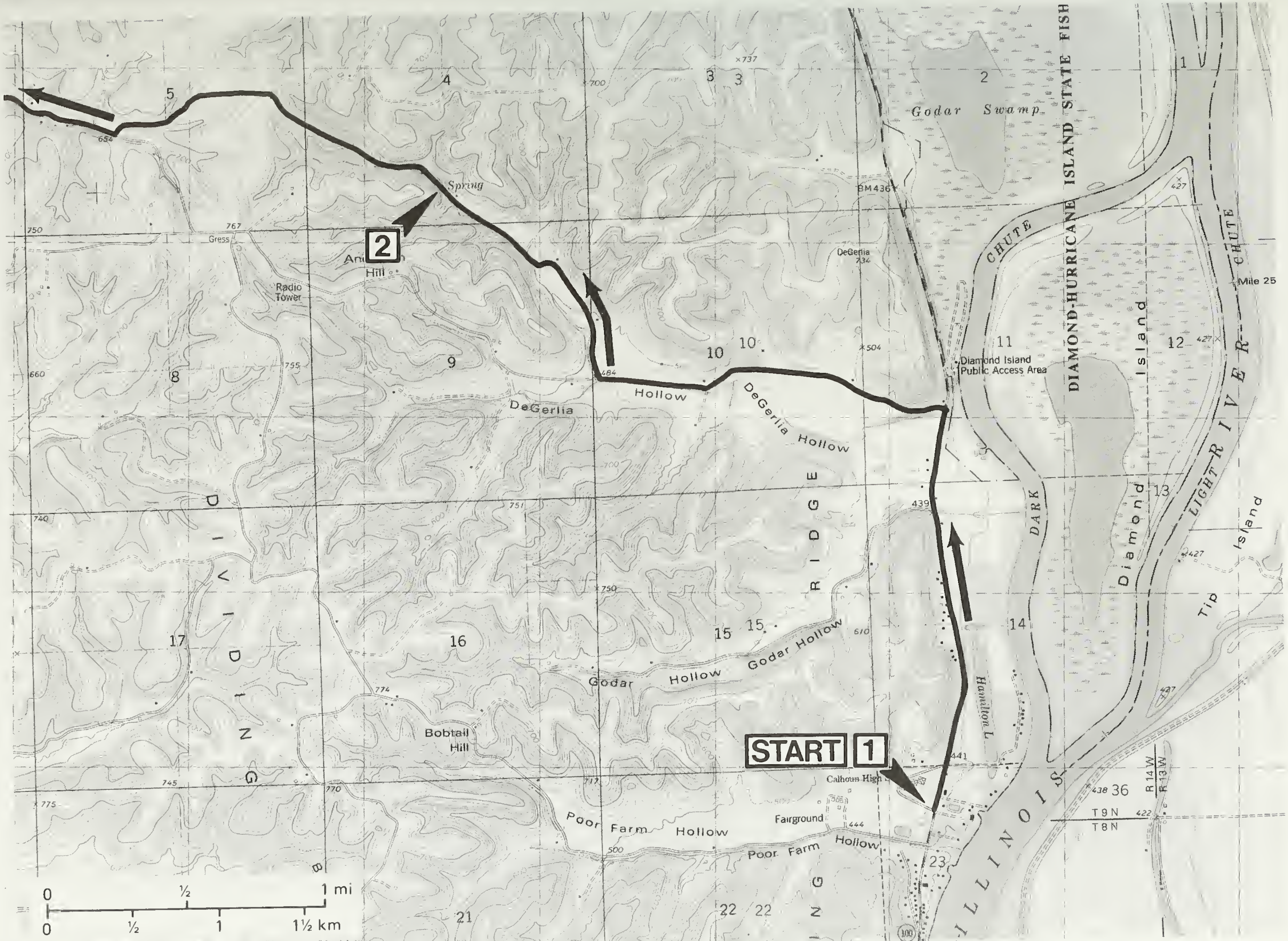
* The number in brackets [39090B5] after the topographic map name is the code assigned to that map as part of the National Mapping Program. The state is divided into 1° blocks of latitude and longitude. The first two numbers refer to the latitude of the southeast corner of the block; the next three numbers designate the longitude. The blocks are divided into sixty-four 7.5-minute quadrangles; the letter refers to the east-west row from the bottom, and the last digit refers to the north-south column from the right.


START
1
2
DIAMOND-HURRICANE ISLAND STATE FISH
Godar Swamp
Diamond Island
Public Access Area
CHUTE
DARK
LIGHT RIVER
ILLINOIS
Diamond Island
Tip Island
Mile 25
Hamilton L
Calhoun High
Fairground
Poor Farm Hollow
Godar Hollow
DeGerlia Hollow
RIDGE
DIVIDING
Bobtail Hill
Radio Tower
Gress
Spring
BM436
T9N
T8N
R14W
R13W
0
½
1 mi
0
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1
1½ km

Calhoun High School housed the National Guard units involved in flood defense in this area. The elementary school became the feeding center for flood relief workers. Meals were prepared there and distributed to Hamburg and Kampsville. Calhoun Elementary also housed the unemployment office as well as the headquarters of the Federal Emergency Management Agency. Firemen were also housed at Calhoun Elementary School. The gymnasium became the commissary for flood victims. Kindergarten classes were held in a church basement and a convent, and pre-kindergarten was held in the American Legion building. St. Norbert's Grade School became the post office and the medical center after the sandbag levees failed to hold and flooding forced them to move. We were fortunate there were no major medical emergencies.

Calhoun Junior High School in Kampsville was used as a storage facility for flood victims' furniture. The kitchen and commodities were used to feed people until the kitchen was surrounded by water.

Then there was the problem of transporting fuel into Calhoun County. Traffic was a problem during the day, so gasoline tankers were brought into the area under police escort on the upland county roads between 1:00 and 5:00 in the morning.

I didn't realize I was a flood victim until my wife, who teaches in Jerseyville, was faced with a daily commute of nearly 105 miles roundabout because of the flood. She decided to stay in Jerseyville during the week and come home only on weekends. That left me at home with four children.

The most important thing everyone involved in the Great Flood of '93 learned was cooperation. We fought the flood together. There are many good people in the world, but no one ever hears about them. We owe a lot to many good people. Someday I am going to volunteer and help somewhere in a disaster.

Less than 1 year has passed since the flood. On the field trip today, you will see many lingering effects of the flood. You will also see how quickly some areas recover. Take a look at the backside of the south concrete "tepee" at the driveway entrance. The black line near the top was the floodwater level here! In looking back toward the school, you will notice a difference in the turf in the front. The grass was killed in the flooded area, so it was reseeded. The new grass is a slightly different color and texture, compared with the older turf.

When we were finishing our field work in early May, several things vividly impressed us. The trees that survived the flood all showed a "dead line" part-way up their trunks. The lower branches had been under water for so long that they looked dead. We could easily trace the extent and depth of flooding by looking at the trees. Now look across the highway away from the river at the fine materials blanketing the rock debris (talus) on the steeper slopes. In some places, they appear to be notched, which means that flood water was at that level long enough for waves to make a slight bench and notch. In early spring, the slopes below the notches had a skimpier cover of vegetation, and the elevation of the notches lined up with the "dead line" just mentioned.

You will see some slumping on hillsides where saturated earth materials gave way. In some places, people have made conditions worse. As spring turns into summer, some effects will not be easily recognizable. Look around anyway and try to identify some of them.

Miles to next point	Miles from start	
0.0	0.0	Leave Stop 1 and TURN LEFT (north). Use extreme caution entering Illinois route 100.
0.8	0.8	Notice ahead of us the prominent bluff that has a vertical east-facing cliff and a gentle west slope. It is capped by the Valmeyeran (Middle Mississippian) Burlington Limestone.

0.5	1.3	Prepare to turn left.
0.1+	1.4+	CAUTION. Cross the bridge and TURN LEFT (west) onto the blacktop, DeGerlia Hollow Road (2325N, 1730E). The curve just ahead on route 100 restricts vision. Watch out for fast traffic!
0.35+	1.8	CAUTION: narrow culvert.
0.1	1.9	To the right, particularly in the roadcut, heavy rains have caused considerable slumping.
0.15	2.05	CAUTION: narrow culvert.
0.05+	2.1+	An active slump area to the right has produced a 5–6 foot scarp that is well vegetated. Its surface is hummocky and rutted. The toe of the slump continues to ooze down and out onto the road during heavy rains.
0.45+	2.6	Look to the left across the creek. High water has cleaned off the channel banks and exposed gravel. CAUTION: slightly ahead and on the right, the road has been washed out. To the left, gravel bars are exposed in the creek. Also, note that the effects of stream erosion are reduced by the use of "gabions," rock-filled, heavy-gauge wire netting cages. Letting water flow through open spaces in the rocks helps to mitigate its erosive force. Prepare to turn right just ahead.
0.1	2.7	TURN RIGHT (northwest) from DeGerlia Hollow Road (2340N) at Godar Hollow Road T-road (1600E) just before the bridge.
0.25	2.95	CAUTION: narrow culvert. Scars of an old tree-covered and grassy slump lie to the left across the creek. Just ahead and on the right is a former mobile home site that was carved into the loess cover of the hillslope. An excavation into the "platform" is presumably for a basement for a new home.
0.25	3.2	CAUTION: the road curves to the right but is partially washed out at a culvert. After you've made the turn, notice the large bulges in the slope across the creek to the left. They're probably old slumps.
0.25	3.45	Also to the left across the creek is an exposure of greenish gray Kinderhookian (Lower Mississippian) Hannibal Shale. Outcroppings of this shale and the overlying Mississippian Chouteau Limestone are seen more frequently in the western part of this valley. CAUTION: the steel tile just ahead is washed out on the left side.
0.15	3.6+	CAUTION: ford the creek and park off the roadway as far as you can safely. Do NOT block gates or driveways. Please do NOT climb on the exposure, remove rock from it, or do anything that might have a bad effect on the spring!

STOP 2 The spring is owned by Les Sontag, but Mark Godar and his dad (on a nearby farm) maintain it. Local visitors come by and use the spring for "fresh" water. Mark, his father, and Mr. Sontag all use the spring as a source of water for their farms. As we talk about the spring, we'll also view the contact between the Kinderhookian (Lower Mississippian) Chouteau (pronounced "show-toe") Limestone Formation and the underlying Hannibal Shale Formation (NE SE SE SE Section 4, T10S, R2W, 4th P.M., Calhoun County; Hamburg 7.5-Minute Quadrangle [39090B6]).

Water percolating down through the soil covering the top and sides of the hill behind the spring enters the cracks and joints of the Chouteau Limestone. As time passed, weak soil acids in the water enlarged the open spaces in the limestone. The groundwater now moves down through the rock until it encounters the underlying Hannibal Shale, a relatively impervious bedrock unit. Water then moves laterally till it encounters the valley wall, where it forms the spring (fig. 10).

The spring originally developed in the Chouteau Limestone several feet above its base where the flow of water was good and steady. In the last couple of years, the flow near the base increased, probably because the strata were somewhat displaced by stream erosion of the bank. Although water still issues from the original spring, the quantity is much greater now near the base.

To preserve the spring, Mark Godar installed sheet piling into the floor of the creek and used quarried limestone as backfill behind the piling to reduce erosion of the shale. He plans to put packing around the pipe in the crevice, then place hydraulic cement in front of the packing to hold it in place. This procedure should increase the flow and pressure through the pipe, which will then be hooked up to the spring box and tank distribution system (fig. 11).

Chouteau Limestone In the area of this stop, the average thickness of the Chouteau is around 25 to 30 feet. It is 75 feet thick in southernmost Calhoun County. From here, the Chouteau continues to thin for roughly 5 miles to the north, where the upper beds were removed by pre-Burlington erosion (fig. 12). The unconformable contact with the overlying Burlington (Middle Mississippian) strata can be seen best at Stop 9.

In outcrop, the formation is distinguished from other Mississippian rocks exposed in this area by its gray argillaceous character and its chert nodules. These nodules with gray centers and light gray edges are found with scattered, small calcite geodes. When weathered, the Chouteau has a characteristic hackly, thin bedded appearance. It consists of irregular beds of light brownish or

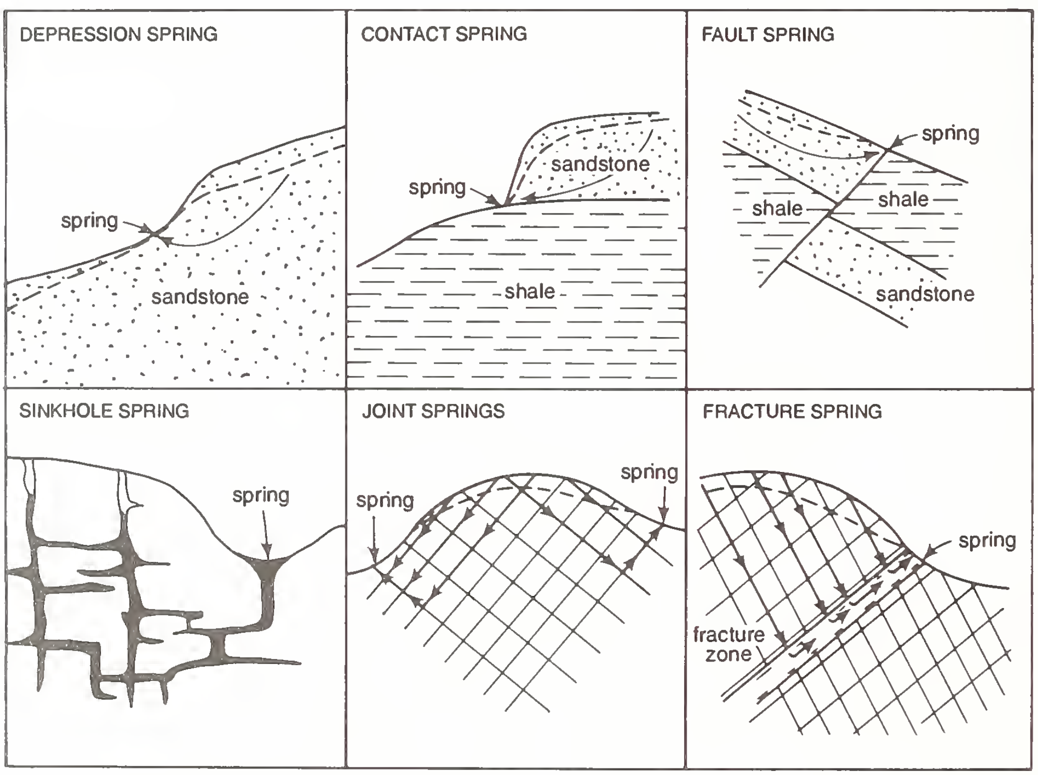


Figure 10 Types of springs.

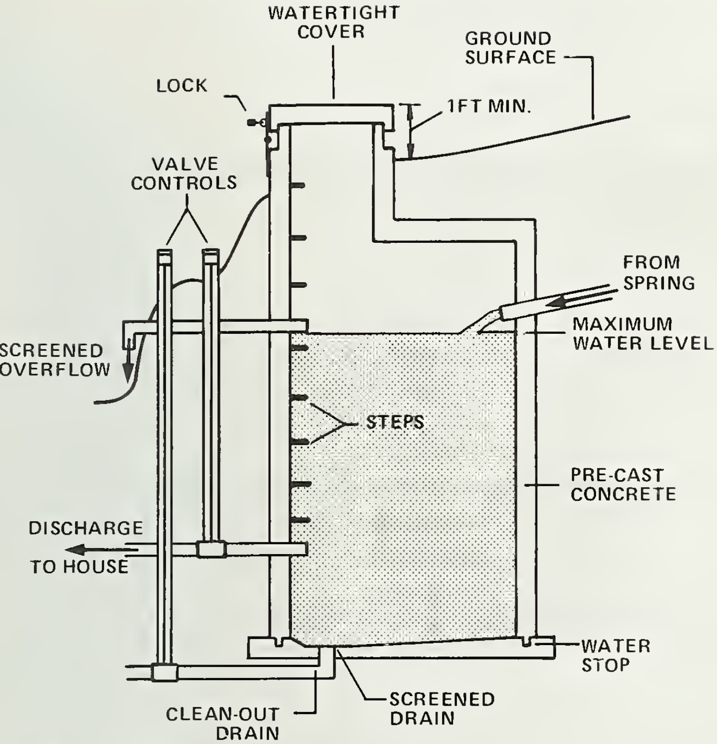


Figure 11 Design of the spring box.

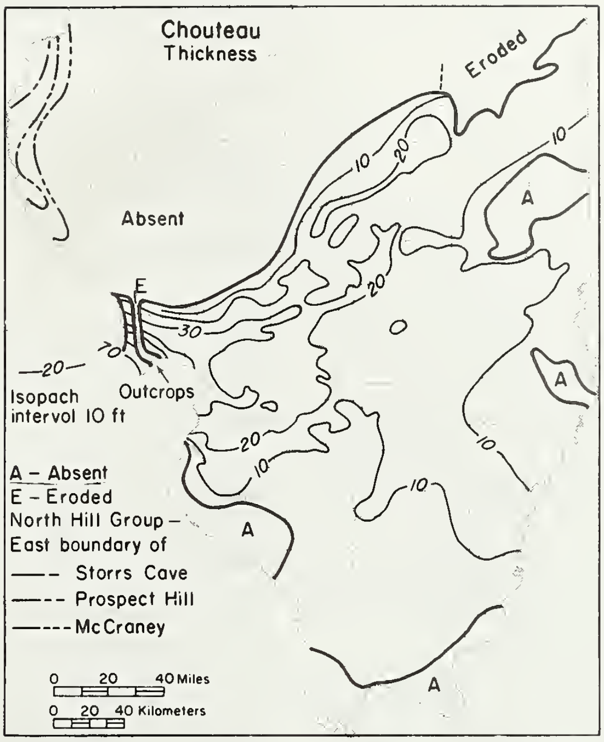


Figure 12 Thickness of the Chouteau Limestone and areal extent of the formations of the North Hill Group (after Buschbach 1952, Workman and Gillette 1956).

greenish gray, lithographic to very fine grained limestone with wavy bedding planes. Bed thickness varies from a few inches to nearly 1 foot.

Common to the Chouteau are marine macrofossils, especially crinoid and brachiopod remains (see Mississippian fossil plate in the back of the guidebook).

Hannibal Shale This is a Kinderhookian (Lower Mississippian) unit that we see in a number of exposures along the trip route today. It consists of shales that are silty in the upper part and vary from greenish gray to black or dark gray. The contact of the shale with the overlying Chouteau is distinct, but the lowermost Chouteau is argillaceous and silty. About 5 miles north of here, the lowermost silty beds of the Chouteau grade laterally to shale and siltstone, classified as part of the upper Hannibal.

0.0	3.6+	Leave Stop 2 and CONTINUE AHEAD (west).
0.2+	3.85	To the right, the Chouteau Limestone forms the creek bottom.
0.1	3.95	To the right on the far valley wall, a scarp has developed below the fence corner where cattle have helped erode the slope.
0.35	4.3	BEAR LEFT (west) at Y-intersection.
0.1	4.4	We are crossing Dividing Ridge in the Calhoun County uplands.

0.2	4.6	Notice that headward growth of small valleys has eroded into the upland surface and produced the rough topography of this area.
0.1+	4.7+	CAUTION. Descend the steep hill.
0.1	4.8+	CAUTION: the ditch on the right drains across and scours the road. The left ditch has expanded at the expense of the road!
0.05+	4.9	BEAR RIGHT (west) at Y-intersection.
0.4	5.3	Gabions in the bend of the stream to the left have mitigated erosion of the cutbank. A short distance downstream, the Chouteau Limestone is exposed along and in the creek. A resistant ledge in the limestone has produced a small waterfall.
0.1	5.4	An exposure of Hannibal Shale (greenish gray at the top, blue gray in the lower part) can be seen across the creek to the left. It is exposed for some distance just above the water level.
0.2	5.6	The low hills to the right are remnants of terraces that developed in this valley during the Ice Age. (See *Pleistocene Glaciations in Illinois* at the back of this booklet.)
0.1+	5.7+	CAUTION. Part of the road has washed away at an old bridge. To the left across the creek behind the mobile home is an exposure of Hannibal Shale overlain by Chouteau Limestone.
0.15+	5.9	Thick Hannibal Shale is exposed to the left across the creek. The steep slope above the shale is held up by the resistant Chouteau Limestone. On the right side of the exposure, a couple of large blocks of limestone have slipped down the slope.
0.1	6.0	Note terraces above the road to the right.
0.05	6.05	The house to the left is located on a lower terrace. About 300 feet southwest of the house is a thick exposure of Hannibal Shale in the creek bank. Several resistant silty layers stand out prominently across the exposure.
0.35	6.4	In the creek bank to the left is a large exposure of Hannibal Shale that is blue gray in the lower part. The upper part is greenish gray but covered over by loess and surface materials that are 12 to 15 feet thick. The shale exposure is about 30 to 35 feet thick; the base is not exposed. The Chouteau is not exposed here; it is covered by loess and surface materials. Just west of this exposure, an old valley was cut down through the Hannibal Shale and then later filled with slackwater silts and loess. CONTINUE AHEAD (west).
0.55+	6.95+	CAUTION: narrow culvert.
0.05	7.0+	The upper terrace on the right is locally persistent.
0.05	7.05	To the left across the creek is an exposure of the lowermost Kinderhookian Horton Creek Formation and the underlying Upper Devonian Louisiana Limestone.

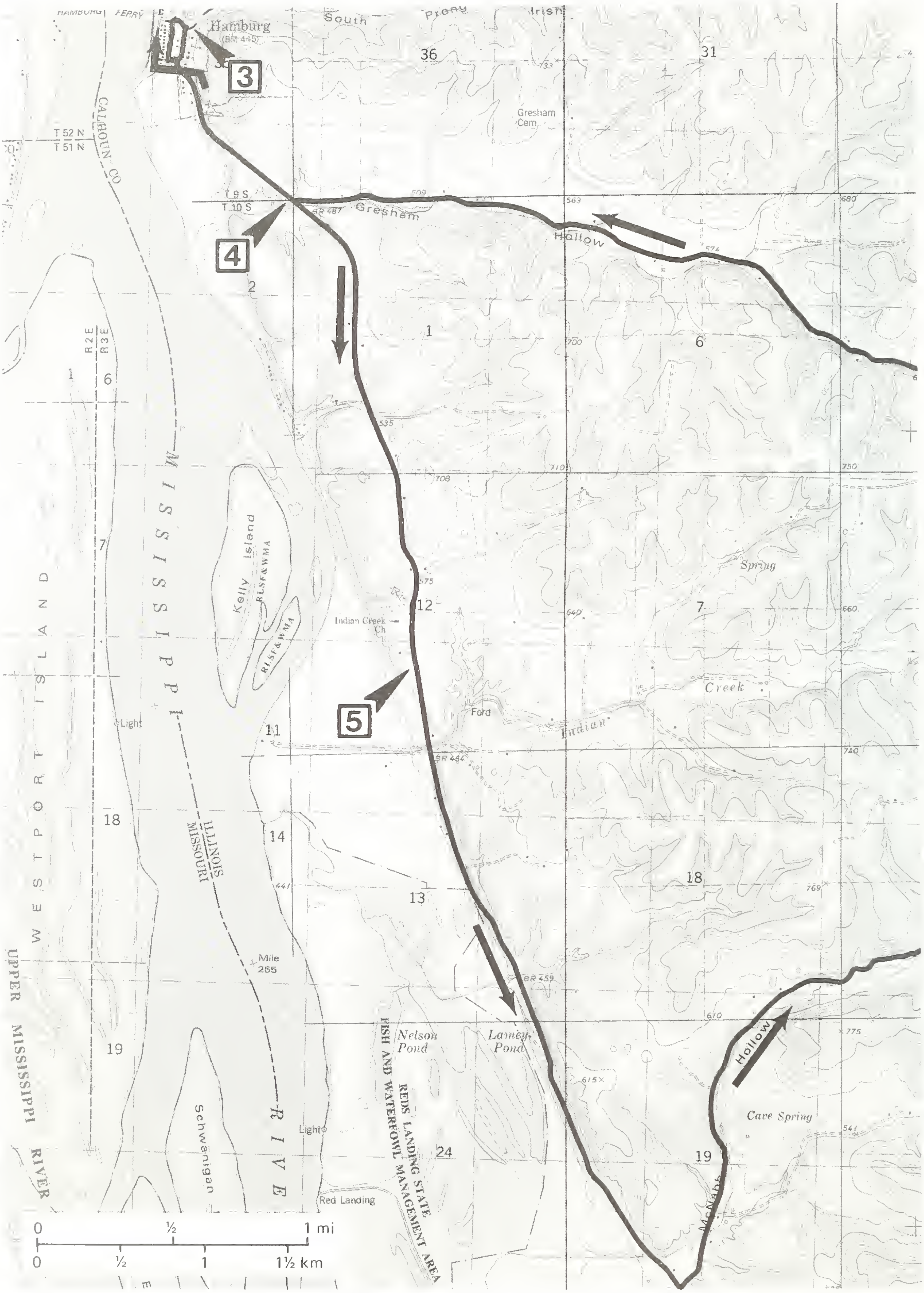
0.3+	7.35+	STOP: 1-way at T-road (Gresham Hollow Road [2500N] and Mississippi River Road [1210E]). TURN RIGHT (northwest).
0.05+	7.45+	The road cuts through Wisconsinan Peoria Loess.
0.4+	7.9+	CAUTION: enter town of Hamburg.
0.15+	8.05+	Cross the creek from Irish Hollow and TURN LEFT (west) at T-intersection.
0.05	8.1+	TURN RIGHT (north) at T-intersection.
0.1+	8.25	TURN RIGHT (east) at intersection.
0.05+	8.3+	BEAR RIGHT (south) at Y-intersection and PARK. Please do NOT block driveways and intersections. CAUTION: traffic can be heavy at times!

STOP 3 One of the most interesting Pleistocene (Great Ice Age) exposures in Calhoun County occurs in the roadcut from Irish Hollow (SE NW SW NE Section 35, T9S, R3W, 4th P.M.,Calhoun County; Hamburg 7.5-Minute Quadrangle [39090B6]).

Three main units are exposed on both sides of the roadcut: stream gravels at the base, overlain by the reddish brown massive Roxana Silt, in turn overlain by light brown Peoria Loess (fig. 13).

Gravel The beds and lenses of gravel are composed dominantly of angular white chert, probably washed down from exposures of the Burlington Limestone in the uplands (fig. 14). The angularity of the chert gravels indicates that they were transported only a short distance, too short to round off their edges by abrasion against other pebbles and rocks in the streams. You can also see brownish chert pebbles and perhaps a few quartz and quartzite pebbles. These appear to be reworked Grover Gravel, which is classified as Pliocene–Pleistocene in age and occurs as small

Figure 13 Roadcut exposing the Peoria Loess and Roxana Silt (upper 60% of cut), which overlie local stream gravels.



Hamburg
3
36
31
Gresham Cem.
T 52 N
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CALHOUN CO
T 9 S
T 10 S
Gresham
Hollow
4
2
1
6
R2E
R3E
MISSISSIPPI
Kelly Island
Indian Creek Ch
12
7
Spring
Creek
Indian
Ford
5
11
WESTPORT ISLAND
Light
18
ILLINOIS
MISSOURI
14
13
Mile 255
19
Nelson Pond
Lamey Pond
Hollow
Cave Spring
Schwanigan
RIVE
Light
24
Red Landing
REDS LANDING STATE FISH AND WATERFOWL MANAGEMENT AREA
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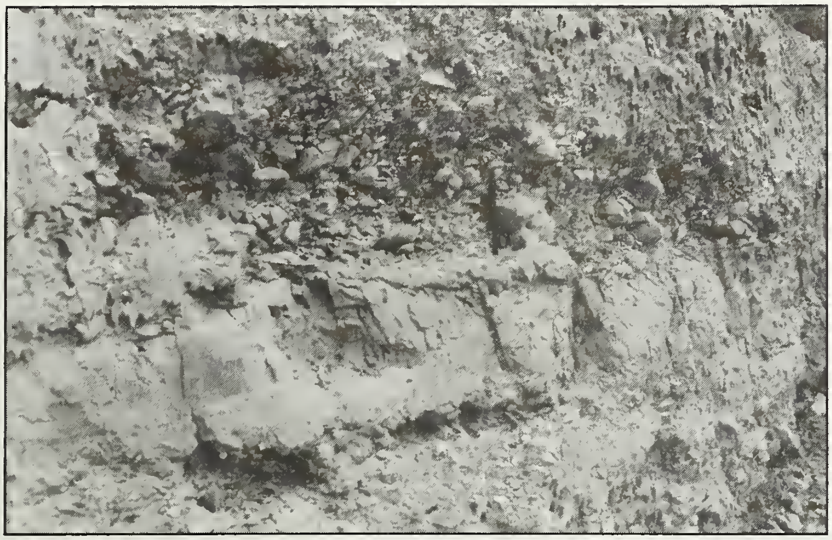


Figure 14 Close-up of the angular fluvial-deposited gravel lenses (mostly chert weathered from local Mississippian bedrock) alternating with fine silt lenses and beds.

relict patches of gravel at the base of the loess on the upland surface of Calhoun County (Willman et al. 1975).

The matrix of the gravels is generally sand and silt, iron-stained to varying degrees, as you can see by the yellow, red, and brown stains in the exposure. Especially notable is a thin but persistent iron-cemented zone generally less than 1/4 inch thick, as well as a 6- to 10-inch-thick zone of gray, blocky silt that is iron-stained to a yellowish to reddish brown in places. Most of these zones are quite variable in thickness, pinch in and out laterally, and display irregular, wavy contacts. From these observations we draw two conclusions: (1) The great vertical and lateral variability represents rapidly changing but very localized conditions of deposition at this exposure. (2) The downward percolation of groundwater was slowed in zones of clay and other fine grained deposits to the point that precipitation of limonite and other iron-bearing minerals took place, resulting in the yellowish to reddish brown staining throughout these units and, in particular, the thin iron-cemented zone. This is an excellent demonstration of how grain size affects groundwater movement.

Loess Overlying the gravels is approximately 3 feet of a massive, well sorted, reddish brown, windblown silt interpreted to be the Roxana Silt of early Wisconsinan age. Overlying the Roxana is about 40 feet (to the top of hill) of Peoria Loess, a light brown, massive, well sorted, windblown silt. These loesses are generally out of reach at this stop, but we will have an opportunity to examine them at the next stop.

Leon R. Follmer, an ISGS geologist specializing in the study of ancient soils, states that all the loesses exposed in Calhoun County show some degree of alteration due to biological activity in the process of soil formation. The loesses here were deposited on a land surface that supported plants and animals. The persistent root traces in loess have led some people to equate loess with soil. In current American practice, loess is the name given to windblown silt, which is the parent material for the soil that develops in it and changes some of its properties.

The Roxana has a weakly expressed soil that affects the whole unit. The basal half of the Peoria is least altered (C horizon of a soil); it is typically calcareous and shows root traces. The upper part becomes increasingly altered upward in the B and A horizons of the modern soil. In places, you can see a strongly leached and bleached layer as the E horizon.

Geologic history If you look across the road and down into the creek valley just to the southeast, you can see gravel bars, sands, and silts in the creek bed of Irish Hollow. One of geology's maxims, "the present is the key to the past," is demonstrated by what's happening in this creek bed. The processes going on today are the same processes that deposited the gravels, sands, and silts we see in this exposure. The only difference is geologic time. Deposition of the Roxana Silt may have begun as early as 75,000 years ago, so we can date deposition of the last gravels back at least that far. If we divide that period of time by the difference in elevation between the base of the Roxana here (about 480 feet msl) and the stream elevation (about 450 feet), we see that it took an average of 2,500 years per foot of downcutting for the stream to erode to its present elevation.

The gravels in the exposure here were deposited by a stream that flowed into the Ancient Iowa/Des Moines Rivers, which during the Great Ice Age occupied much of the what is now the Mississippi River valley. It stretched from several miles south of Muscatine to the confluence with the Ancient Mississippi at the point where the Mississippi and Illinois Rivers meet today. As long as the present Mississippi continues to erode, downcutting will continue in this stream. The Mississippi serves as the base level for this stream; that is, it cannot erode deeper than the level of the Mississippi.

According to Leon Follmer, the oldest gravels here are on the highest parts of the landscape. The younger gravels occur lower on the landscape. The stream contains older gravels and newer lithic debris derived from local bedrock. The younger gravels appear to reflect the cyclic glacial–interglacial conditions of the Pleistocene. The relative age of a gravel layer is determined by the age of the loess that buries it and the nature of weathering in it. The geologic "record" of Calhoun County suggests that most gravels formed just before or during an interglacial stage. At Stop 3, the age of the gravels is late Illinoian to Sangamonian.

Engineering problems During a trip to this area on May 4, 1994, we noted that loess had recently been cleared from the roadway. The slumped blocks of loess had partly blocked the eastbound lane of the road. We will discuss slumping of loess at Stop 4.

0.0	8.3+	Leave Stop 3 and CONTINUE AHEAD (south).
0.1+	8.4+	TURN RIGHT (west) at T-intersection and then STOP: 1-way. TURN LEFT (south) at nearby T-intersection.
0.05	8.45	Cross the bridge over the creek from Irish Hollow.
0.15	8.6	Leave Hamburg.
0.5	9.1	PARK along the road shoulder as far off the pavement as you can safely. CAUTION: visibility for traffic coming from the northwest is poor.

STOP 4a Peoria Loess is exposed on both sides of a roadcut northwest of Gresham Hollow (SE SE SE Section 35, T9S, R3W, 4th P.M., Calhoun County; Hamburg 7.5-Minute Quadrangle [39090B6]).

The Peoria Loess originated as dust swept up from the floodplain where the Mississippi River now flows. During winters when the flow of meltwater from glaciers to the north waned, the floodplain dried out. Prevailing westerly winds blew across the broad flats of drying sediments—an excellent source of the silt that now forms the thick loess deposits spread across most of Calhoun

Figure 15 Peoria Loess exposed in roadcut, where it exhibits typical vertical walls. Note the slumped material, which came from the slump scarp (directly above the geologist). The loess failed along the vertical joints in the cut.

County. The Peoria Loess occurs on upland areas and valley walls through most of the area not covered by Wisconsinan glaciation. The loess is thickest nearest the larger valleys and thins across the uplands away from these valleys.

Loess forms stable vertical walls in well drained roadcuts. When rainwater soaking (percolating) into the ground increases the moisture content of the loess, it becomes less stable and more likely to slump onto the roadway (fig. 15). The northeast-facing cut here is better shaded. Vegetation is fairly high on the slope, and three or four trees are growing on the slope itself. Apparently, when the slope last failed, the soil, grass, and trees all slumped downward as a block, as one mass of material. The bases of the tree trunks are curved, showing that the trees are adjusting to their new angle. The west-facing cut is drier because it receives more sunlight, but it also failed recently, as you can see from the tumbled blocks of loess at the base of the cut. Note the joints in the vertical face of the loess. During the next episode of slumping, blocks of loess will again separate from the main face along these joints. The differences in the appearance of this roadcut are clear in the two photographs of figure 16.

Walk a short distance down the road to the bridge and continue downstream (west) to Stop 4b. If you visit here some other time, *you **must have permission** to enter this property.*

STOP 4b Devonian detritus overlie Silurian strata in the bed of the creek flowing from Gresham Hollow (N½ N½ NE NE Section 2, T10S, R3W, 4th P.M., Calhoun County; Hamburg 7.5-Minute Quadrangle [39090B6]).

The second part of this stop begins at the bridge south of the roadcut where the blacktop (Mississippi Valley Road) crosses Gresham Hollow. The creek cascades down over ledges of light gray Silurian limestone (fig. 17). Take some time to enjoy this picturesque spot, as you walk downstream from the bridge.

A short distance from this site (upstream and in Irish Hollow creek on the south edge of Hamburg), strata from the lowermost Mississippian (Horton Creek Formation) to the Middle Devonian Cedar Valley Formation (fig. 18) are exposed just above the Silurian strata that we see in Gresham Hollow creek. The basal Cedar Valley unit, the Hoing Sandstone Member, is a brown sandstone that immediately overlies Silurian strata exposed at the bridge over Irish Hollow creek.

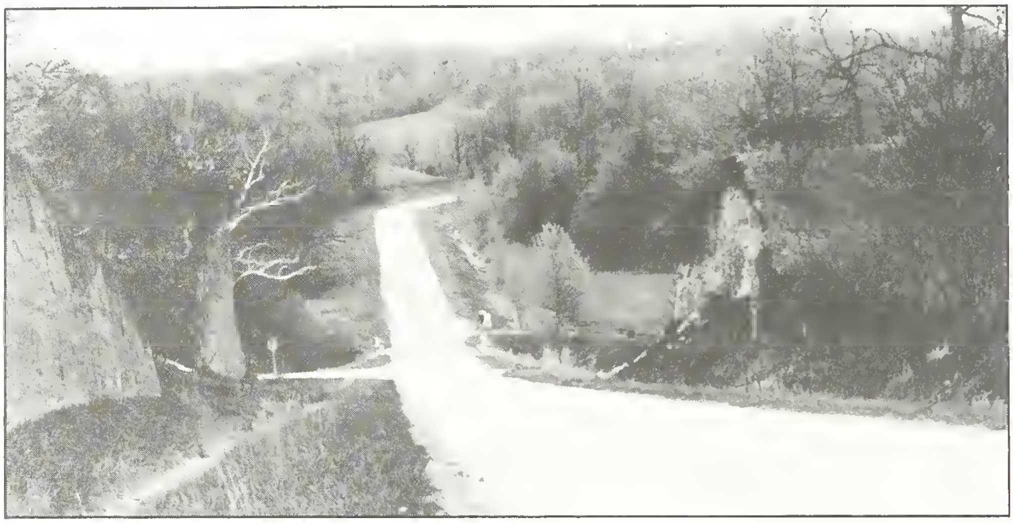


Figure 16 Looking south downhill. Peoria Loess is exposed in the roadcut. Bottom photo was taken in 1983. Top photo, taken in 1994, shows how much vegetation has overgrown the cut.

The Joliet Formation here is a hard, massive to thin bedded, finely crystalline limestone that is light gray with pink mottling. The Joliet extends from northeastern Illinois into Calhoun County, where it is restricted to a narrow belt only 3 miles southward from this outcrop, its northernmost exposure.

The following description of the Joliet (fig. 18) is from the ISGS field notes, recorded by H.B. Willman and H.A. Lowenstam in 1947.

Limestone, very crinoidal, pink to greenish gray on weathered surface, much thinner bedded (½ to 1 inch), thin below and more coarsely crinoidal, basal 6 inches is argillaceous and makes strong reentrant.12 ft 2 in.

Limestone, crinoidal, pink and greenish gray, massive, with faint wavy partings.3 ft 1 in.

Limestone, as above, lower 5 inches weathers back.2 ft 4 in.

Limestone, greenish gray to pink, argillaceous, shaley beds, prominent reentrant.1 ft 10 in.

Limestone, gray, vuggy, crinoidal lenses, some pink, gray clay partings and lenses, lower 1 foot weathers nodular and has a reentrant. Contains *Stricklandia pyriformis*.2 ft 3 in.

Limestone, very fine grained, light greenish gray, slightly argillaceous, many green clay partings but tight and wavy, fair break in middle, *Pentamerus oblongus*, locally abundant about 1.5 feet below top.3 ft 6 in.

Limestone, gray, many weak wavy partings, weathers in 6 inch to 2 foot ledges.3 ft 2 in.

Figure 17 Limestones of the Silurian Joliet Formation exposed in Gresham Hollow Creek at Stop 4b.

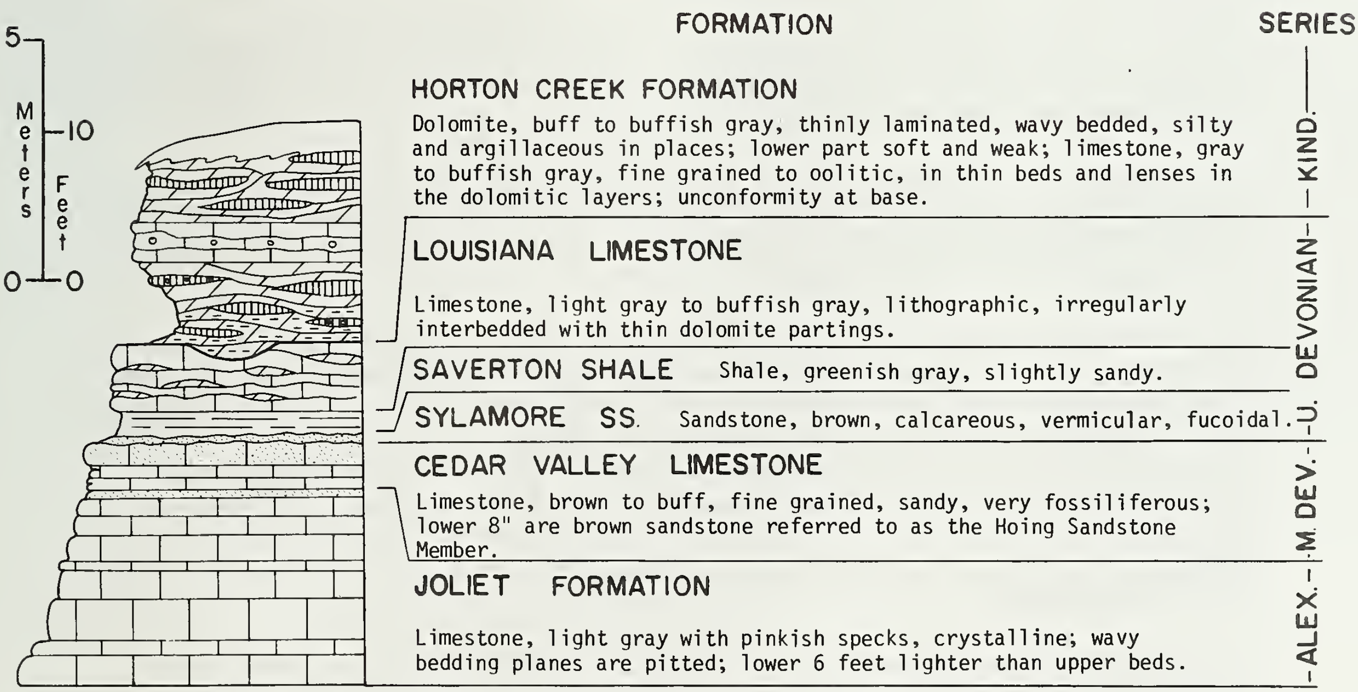


Figure 18 Generalized section of bedrock strata exposed in the vicinity of Stop 4.

Limestone, fine grained, gray, contains several 1–2 inch beds, strongly laminated, upper surface contains abundant bioturbation in form of tubular burrows (commonly called fucoids).2 ft 2 in.

Limestone, fine grained, gray, weak bedding planes, wavy, usually in massive ledge with bed below.1 ft 2 in.

Limestone, fine grained, brownish gray, slightly crinoidal, very cherty.1 ft 2 in.

Limestone, gray brownish, bright green stylolitic clay partings, little chert, semi-lithographic.2 ft

The Joliet Formation is the basal formation of the Niagaran Series (Middle Silurian) in Illinois. A prominent but very smooth bedding plane marks the contact with the underlying Kankakee Formation. The contact is well exposed in this creek downstream from the bridge.

The Kankakee Formation of the Alexandrian Series (lower Silurian) consists of the oldest strata in the section. The Kankakee is a hard, massive, finely crystalline to dense, pure, tan gray limestone mottled with green stains. Irregular bedding surfaces are common and a peculiar weathering surface marked by pits is characteristic of this unit. Although quite similar in appearance to the overlying Joliet Limestone, the Kankakee can be distinguished from it only by comparing differences in the fossils.

0.0	9.1	Leave Stop 4 and CONTINUE AHEAD (southeast).
0.05	9.15	Cross creek from Gresham Hollow.
1.7+	10.85+	PARK along the road shoulder as far off the pavement as you can safely. CAUTION: fast traffic! And watch out for a single-strand electric fence along part of the shoulder!

STOP 5 The Mississippi Valley lowlands and the Missouri uplands spread out before us to the west and southwest (SE SE NE SW Section 12, T10S, R3W, 4th P.M., Calhoun County; Hamburg 7.5-Minute Quadrangle [39090B6]).

The Mississippi River Valley, about 4½ miles wide here (fig. 19), is one of the most prominent topographic features in the Hardin field trip area. The bedrock floor of the valley is less than 300 feet msl, whereas the surface of the floodplain ranges from 435 to 445 feet msl. There is a considerable amount of valley fill in this vicinity.

Before Wisconsinan time, this large bedrock valley was occupied by the Ancient Iowa–Des Moines Rivers, which apparently had their headwaters in northern Iowa and southern Minnesota. Late Wisconsinan glaciers blocked the Ancient Mississippi River, which occupied much of the present lower Illinois River valley. The level of the Ancient Mississippi River rose high enough to overtop a low divide near Cordova in Rock Island County. Water levels remained high long enough to entrench the Ancient Mississippi across the Quad City area to south of Muscatine, Iowa, where the new path of the Mississippi joined the Iowa River in its present position. A short distance downstream near Keokuk, Iowa, the Mississippi was joined by the Des Moines River on its journey southward.

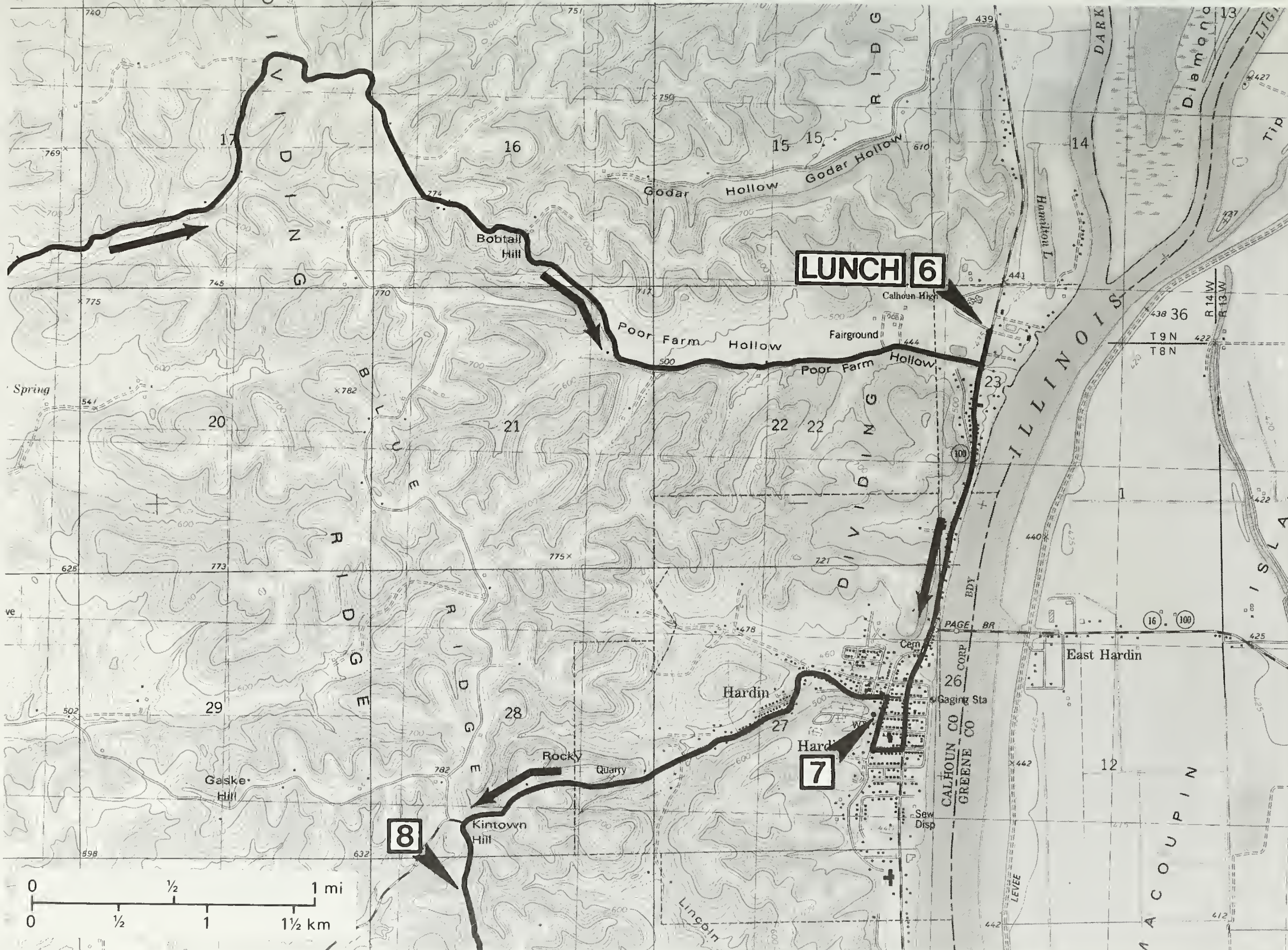
Large areas of the lowlands can flood during periods of prolonged rainfall. The Great Flood of 1993 inundated the the valley—wall to wall.

0.0	10.85+	Leave Stop 5 and CONTINUE AHEAD (south).
0.15–	11.0	Thick loess is exposed in the roadcut to the left.
0.15	11.15	CAUTION: narrow bridge.

Figure 19 Looking to the south-southwest of the Mississippi River floodplain while the river was in flood in 1983. Beyond the trees, flood water stands in the fields.

0.1	11.25	To the left, note the overhanging ledges of Silurian limestones. The lower tan, dolomitic Edgewood Formation is much more readily eroded than the overlying gray Kankakee Formation.
0.75+	12.0+	CAUTION: narrow culvert. Slightly ahead and to the left is a large slump block that has slid down toward the road.
0.1+	12.15	To the left, the Edgewood Formation has a spongy appearance and contains some "cave" openings, which actually reach only 12 to 15 feet back into the bluff. About six "caves" can be found within about 1/10 mile of here.
0.25	12.4	To the left, note the sharply rounded hilltops between several gullies emptying into the valley.
0.7	13.1	Across the fence to the left is a pit that exposes the greenish shale of the Ordovician Maquoketa Group, the oldest strata exposed on this field trip.
0.05+	13.15+	CAUTION: narrow bridge.
0.15+	13.3+	TURN SHARP LEFT (northeast) from Mississippi Road (1340E) at T-road onto gravel Jug Hollow Road (2110N).
0.2+	13.5+	CAUTION: narrow wooden bridge.
0.05+	13.6+	Slackwater silts of the Equality Formation are exposed in several road cuts to the left. Gravel deposits lie at the base.
0.15	13.75+	CAUTION: to the right, the road has been partly washed away by the creek.
0.6	14.35+	The houses to the left are built on terrace remnants.
0.55+	14.95	CAUTION; the narrow culvert has been washed out on both sides.
0.2+	15.15+	Chouteau Limestone floors the creek to the right.

0.05	15.2+	CAUTION: washout on the right.
0.4+	15.65	To the right at the head of the ravine is a refuse dump becoming overgrown with weeds and brush. Apparently, it has not been used much recently. Even so, runoff from it can pollute the creek and wells farther down the hollow. BEAR RIGHT around the head of the ravine.
0.15+	15.8+	STOP: 1-way at T-intersection (2280N, 1480E). TURN RIGHT (south) on Blue Ridge Road.
0.05+	15.85+	To the left is another ravine that has been used for dumping. The dump is not quite as large as the previous one.
0.7+	16.6	STOP: 1-way at T-intersection (2230N, 1520E). TURN LEFT (northwest) to Poor Farm Hollow.
0.4	17.0	CAUTION; prepare to descend steep Bobtail Hill.
0.05+	17.05+	To the left is a mass of chert that weathered out of the Mississippian Burlington Limestone.
0.05	17.1+	Blocks of Burlington Limestone are exposed around the curve. Notice the large masses of chert in the stone.
0.05	17.15+	The exposure of the contact between the Burlington and the underlying Chouteau is somewhat slumped.
0.2	17.35+	To the right are small exposures of the drab greenish gray Hannibal Shale.
0.1	17.45+	CAUTION: rough road.
0.15	17.6+	Hannibal Shale lies to the right.
0.25	17.85+	Horton Creek Formation is exposed on the right.
0.2	18.05+	To the right across the creek is an exposure of Equality Formation, 15 to 18 feet thick. Slackwater silts of a somewhat blocky texture, lenses of angular gravels, and some pods of finer sandy material can be seen. The sandy material is yellow brown, but the overall exposure has a somewhat pinkish cast (Roxana).
0.2	18.25+	Limestone ledge is exposed (Horton Creek Formation) in the creek bottom to the right.
0.05	18.3+	On the right is more Horton Creek limestone. The upper part is wavy bedded and 3 to 4 feet thick; the top is somewhat slumped. Below that is a blockier, denser, lighter gray limestone that is about 1½ to 2 feet thick down to water level.
0.1	18.4+	To the right across the creek is a knob of Equality Formation silts and loess; 9 or 10 feet are exposed at the top. The bottom part is concealed by slumping.
0.05	18.45+	To the left is a terrace remnant.


LUNCH 6
7
8
Calhoun High
Fairground
Poor Farm Hollow
Godar Hollow
Bobtail Hill
Hamilton L
ILLINOIS
Hardin
East Hardin
Cem
Gaging Sta
Sew Disp
CALHOUN CO
GREENE CO
CORP
BDY
PAGE BR
LEVEE
Rocky
Quarry
Kintown Hill
Gaske Hill
Lincoln
Spring
DIVIDING RIDGE
BLUE RIDGE
RIDGE
MACOUPIN
ISLAN
Diamond
DARK
Tip
T9N
T8N
R14W
R13W
0 ½ 1 mi
0 ½ 1 1½ km

0.15	18.6+	To the right across the creek, more of the Equality Formation is exposed. The elevation of the top of the exposure is approximately the same as the top of the terrace remnant to the northwest.
0.25	18.85+	STOP: 1-way at T-intersection with route 100 (2180N, 1720E). TURN LEFT (north) on Illinois River Road.
0.1+	19.0+	TURN LEFT (northwest) at the entrance to Calhoun High School. Please follow the parking directions. After lunch, we'll resume calculating our mileage from this entrance.

STOP 6 After lunch, we'll talk more about *The Great Flood of 1993* and the importance of topographic maps (drive entrance, near center SE NW NW Section 23, T10S, R2W, 4th P.M., Calhoun County; Hardin 7.5-Minute Quadrangle [39090B5]).

Land surveying in Illinois A map is a representation on a flat surface of all or part of Earth's surface and its features drawn to a specific scale. At this stop, we will discuss the land survey system in Illinois. An examination of the 15- and 7.5-minute quadrangle maps for the field trip area shows that section lines in Illinois define a nearly perfect rectangular grid. You'll note some differences when comparing the east and the west sides of the Illinois River, but more about that later. Also, the land survey system appears much different on the Missouri side of the Mississippi River.

In 1804, initial surveying from the 2nd Principal Meridian (P.M.) (fig. 20) continued westward from Vincennes, Indiana; it became the basis for surveying about 10% of what is now eastern Illinois. In 1805, the 3rd P.M. was designated as beginning at the mouth of the Ohio River and extending northward to facilitate surveying new land cessions. During March 1806, surveying commenced northward on both sides of the 3rd P.M. An initial base line survey point was established, then later arbitrarily moved northward 36 miles to coincide roughly with the base line of the 2nd P.M. Still later, the "Beardstown Base Line" and the 4th P.M. were established for surveying areas west of the Illinois River.

The township and range system permits accurate identification of most parcels of land in Illinois, and thus facilitates the sale and transfer of public and private lands. In the early 1800s, each normal township was divided (to the best of the surveyor's ability) into 36 sections, each of which was 1 mile square and contained 640 acres (see route maps).

Township and range lines do not form a perfect rectangular grid over the state (fig. 21) because of the use of different base lines and principal meridians, and because minor offsets were necessary to compensate for Earth's curvature. The surveying corrections that produced the minor offsets were usually made at regular intervals of about 30 miles.

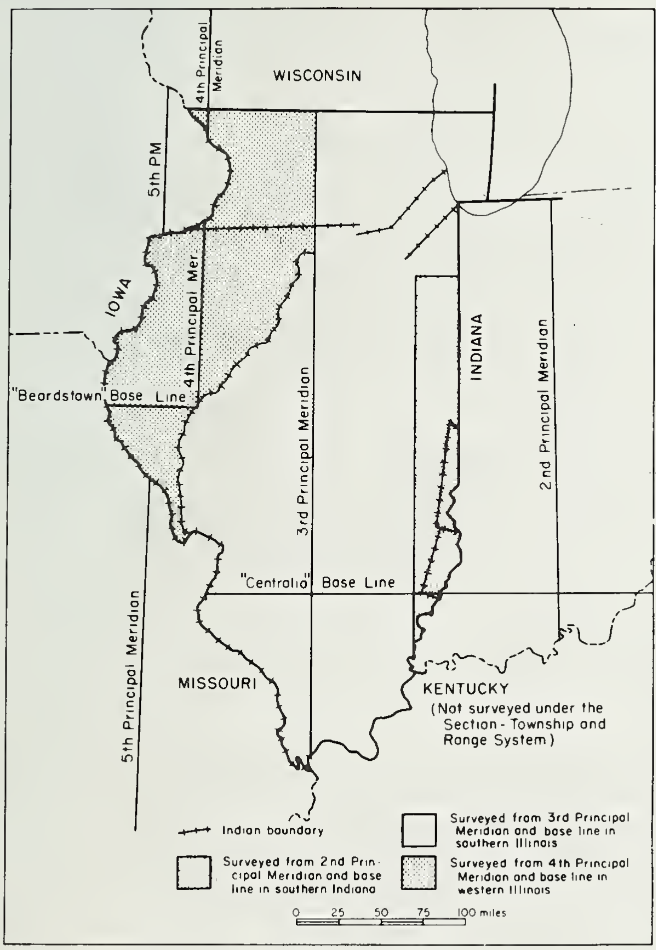
In the Hardin field trip area, two different base lines and principal meridians were used to survey the region. East of the Illinois River, the "Centralia Base Line" and the 3rd P.M. were used. West of the Mississippi River, Missouri was surveyed from its base line and the 5th P.M. Some section numbers are repeated on both sides of the river and only slightly offset. The same thing happens in eastern Illinois, where the 2nd P.M. from Indiana was used. Look at the other route maps to see what other differences you can find.

What is a topographic map? Natural and cultural features (rivers, streams, levees, roads, buildings) show up on topographic maps, but they also show the configuration, or *topography*, of land surface. Variations in elevation of the land surface are shown by contour lines, which connect points of equal elevation. These lines represent the *contours* or shape of the land surface. As you become familiar with topographic maps, you begin to see the third dimension and identify

areas of high and low elevation. Take a look at any topographic maps you have at home or school. You'll have a better understanding of the land in and around your town.

Topographic maps were invaluable tools for the National Guard, engineers, emergency workers, farmers, and townspeople during the Great Flood of 1993. Given a prediction that the river would crest at a certain elevation, relief workers could check their maps to find out which parts of a town would be under water, how many acres were likely to be flooded, which roads were high enough to get trucks to the levee, whether the town's water treatment plant was in danger, and who needed to be evacuated. And of course, they'd know where to start sandbagging. Even pilots flying for the National Guard used topo maps to interpret the terrain and what lay under the flood waters. But that was not the extent of their usefulness.

Flooding is a spatial problem, according to the ISGS geologists. So they carried topographic maps, which provide a "3-D" view of the land surface, when they went into the field after the flooding. Topographic sheets at 1:24,000-scale (1 inch on the map equals about 2,000 feet on the ground) were important for mapping the aftermath. Geologists plot their data on the 1:24,000-scale



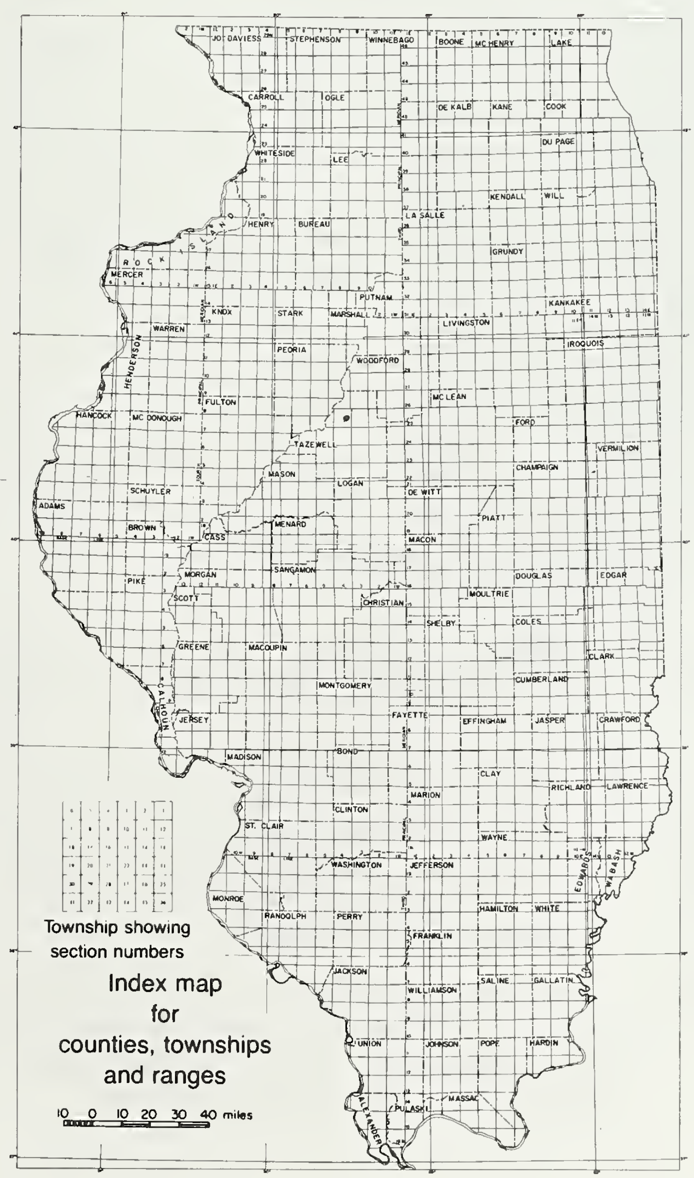


Figure 20 *above* Principal meridians and base lines of Illinois and surrounding states (Cote 1978).

Figure 21 *right* Index map (Cote 1978).

sheets. Even small undulations on the landscape could be pinpointed on the topo maps, which were mainly used (along with aerial photos) to note tree lines, spot buildings and other cultural features, and fix locations for sampling and measurement of flood deposits.

ISGS geologists were particularly interested in erosion, transportation, and deposition of sediments during the 1993 flooding. Mapping the extent of sedimentation due to flooding would give them a good measure of the geologic processes that were shaping the land during the flood.

You can learn to interpret topographic maps too. If you have one of these maps at home or school, try to find some of the oddities mentioned earlier. Maybe you need to study this very informative type of map further. ISGS has a free index of topographic maps of Illinois. Order a topo map or two of your home area.

0.0	19.0+	Leave Stop 6. STOP: 1-way at SR 100. TURN RIGHT (south) on the Illinois River Road.
0.1	19.1+	Ahead and slightly to the right is a prominent bluff. The Burlington Limestone is the uppermost bedrock strata in this bluff. Silurian dolomite crops out along the base of the bluff heading south toward Hardin and again from 1.5 miles south of the bridge on south for 8 miles.
0.6	19.7+	CAUTION; congested area lies ahead in the north part of Hardin.
0.3	20.0+	CAUTION: T-intersection from left from Page Bridge. A southward dip of strata into the Hardin Syncline can be seen just above and to the south from this junction. CONTINUE AHEAD (south) into Hardin.
0.25	20.25+	STOP: 4-way at Main Street. CONTINUE AHEAD (south) on Park Street.
0.15	20.4+	TURN RIGHT (west) on Kennedy Street.
0.1	20.5+	STOP: 3-way at County Road. TURN RIGHT (north).
0.1+	20.65	PARK along the street but do NOT block driveways, streets, or fire hydrants!

STOP 7 At this stop, we will examine an exposure of Chouteau Limestone overlain by Burlington–Meppen Limestone (NW NW NE SE Section 27, T10S, R2W, 4th P.M., Calhoun County; Hardin 7.5-Minute Quadrangle [39090B5]).

The tilted Chouteau and Burlington Limestones crop out on the northeast flank of the Hardin *Syncline* (fig. 22). Strata at this site are a clear indication that we are on the flank of the syncline (a U-shaped downfold) where the strata dip approximately 10° to the southwest and strike N35° W. This dip has "pulled" the Burlington down to road level here by the watertower. The Hardin Syncline has about 250 feet from the deepest part on a particular stratum up to the last or highest encircling contour line (negative closure) (fig. 22).

The Burlington–Meppen contains abundant crinoid remains, as does the uppermost Chouteau at this location. The Meppen is known to contain common calcite-filled geodes, and this location is no exception. Some of the geodes represent former crinoid calyces. Brachiopods and corals are also found in the limestones at this location.

Figure 22 Local structures in the vicinity of the field trip area. The black dot marks Stop 7 on the north-northwest flank of the Hardin Syncline.

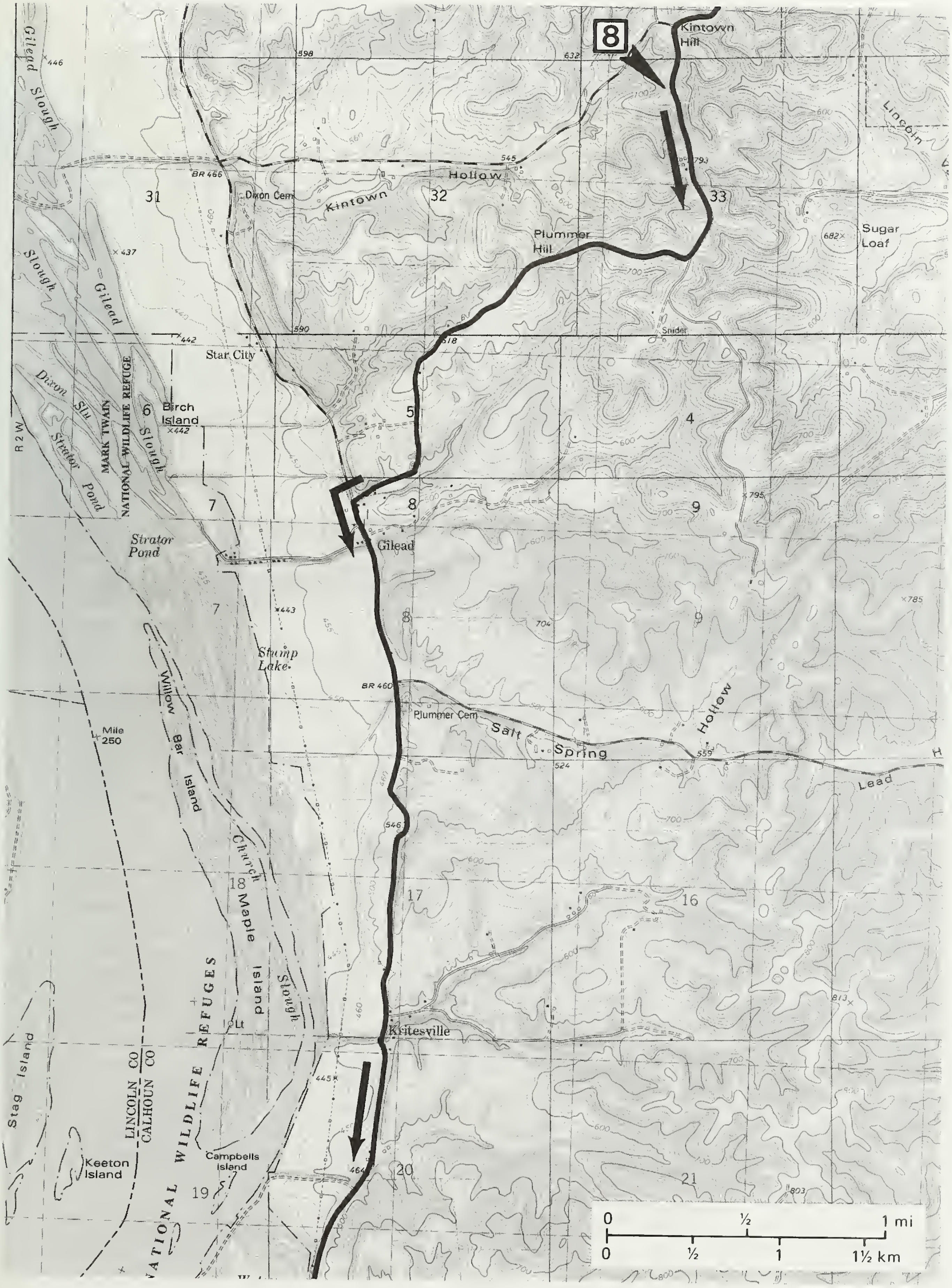
0.0	20.65	Leave Stop 7 and CONTINUE AHEAD (north).
0.05+	20.7+	STOP: 4-way at Main Street. TURN LEFT (west).
0.3+	21.05	BEAR LEFT around the curve.
0.3	21.35	To your left across the creek, there is a stand of *Equisetum*, a modern horsetail. This plant has survived from the Pennsylvanian Period.
0.1	21.45	Jog left and then right across the culvert.
0.2	21.65	Ascend a steep hill and leave Hardin.
0.2	21.85	To the right is an abandoned roadside quarry in the Mississippian (Valmeyeran) Burlington Limestone. Note the very cherty nature of part of the exposure. Some zones in this exposure are quite fossiliferous. CONTINUE AHEAD (west) up the hill.
0.45+	22.3+	The ravines on both sides of the road just before the intersection have been used for refuse disposal in the not too distant past!
0.05	22.35	CAUTION: Y-intersection (2010N, 1540E). TURN LEFT (south) onto Plummer Hill Road (gravel).
0.3	22.65	PARK along the road shoulder as far off the pavement as you can safely. CAUTION: narrow road. Watch for traffic!

STOP 8 At this locality, we are atop "Dividing Ridge," a highly resistant bedrock spine between the Illinois River Valley to the left (east) and the Mississippi River Valley to the right (west) (SW NE NW Section 33, T10S, R2W, 4th P.M., Calhoun County; Hamburg 7.5-Minute Quadrangle [39090B6]).

The Dividing Ridge is a remnant of the Calhoun Peneplain, an erosional surface of low relief that was uplifted and carved by the large rivers flowing mainly during the Pleistocene.

Please refer to the section, *Pleistocene Glaciations in Illinois*, in the back of this booklet. On the page entitled, "Sequence of Glaciations and Interglacial Drainage in Illinois," you'll find a series of small maps of the state. Through most of the Ice Age, the Ancient Iowa and Des Moines Rivers flowed in the valley that holds the present Mississippi River. The Ancient Mississippi River flowed in most of the southern segment of the present Illinois River Valley, The last glacier to cross Illinois during late Wisconsinan time permanently deflected the ancient river into the valley occupied by the present river. Meltwater floods, particularly the Kankakee Flood, established the present upper Illinois River, excavated the valley between Peoria and Pekin, and eroded the valley to its present size. Normally, the Illinois River is an "underfit" stream because its floodplain is so much larger than the river that now flows in it.

Meltwater floods not only eroded these valleys, they also aggraded or built up their valley floors by depositing a great deal of sediment that had melted out from ice to the northeast. This is particularly true for the lower Illinois River Valley, which has a very low gradient of about 0.1 foot per mile along the 30-mile segment from Kampsville to its confluence with the Mississippi. So this part of the Illinois River is particularly prone to flooding. During the flood of 1993, the great volumes of

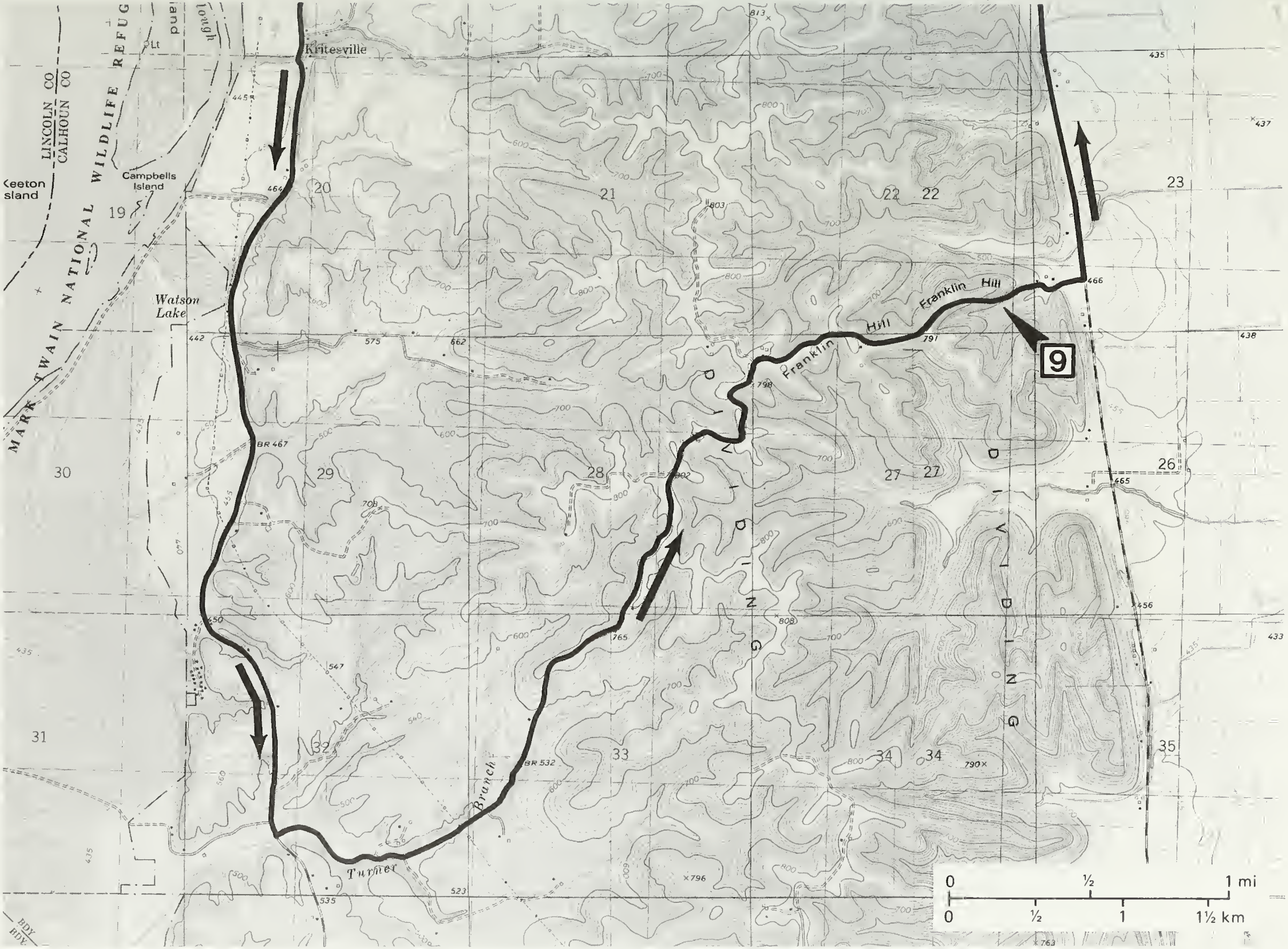


8
Kintown Hill
Kintown Hollow
Dixon Cem
31
32
33
Plummer Hill
Sugar Loaf
Lincoln
Gilead Slough
Slough
Gilead
Star City
Snider
Dixon Slu
Strator Pond
MARK TWAIN NATIONAL WILDLIFE REFUGE
Birch Island
6
5
4
R 2 W
7
8
9
Gilead
Strator Pond
7
8
9
Stump Lake
BR 460
BR 466
Plummer Cem
Salt Spring Hollow
Lead
Mile 250
Willow Bar Island
Church
18
Maple Island
Slough
17
16
NATIONAL WILDLIFE REFUGES
Lt
Kritesville
Stag Island
LINCOLN CO
CALHOUN CO
Keeton Island
Campbells Island
19
20
21
0
½
1 mi
0
½
1
1½ km

water coming down the Mississippi blocked water flowing down the Illinois. Because water was prevented from flowing out of the Illinois River valley, Mississippi flood water backed into the Illinois River and caused it to temporarily flow upstream. Consequently, farmland in the lower Illinois River valley was inundated by backwater flooding.

If you can imagine both river valleys full of floodwater from bluff to bluff, you can imagine not only what the flood of 1993 looked like, but also what the area must have looked like during the times of glacial melting about 14,000 years ago.

0.0	22.65	Leave Stop 8 and CONTINUE AHEAD (south).
0.6	23.25	CAUTION: Y-intersection (1925N, 1540E). BEAR RIGHT (west) around curve.
0.25	23.5	To the left is an excellent view of the Mississippi Valley and the Missouri skyline in the distance.
0.35	23.85	CAUTION: descend steep Plummer Hill. Be sure to downshift.
0.55	24.4	Another view of skyline to the left. Descend the hill farther.
0.05	24.45	Notice slumping along the roadcut to your left.
0.5	24.95	STOP: 1-way at T-intersection (1780N, 1425E). TURN LEFT (south) onto Mississippi River Road and cross the creek into the community of Gilead, the first county seat of Calhoun County (1821–1847).
0.6	25.55	To the left (east) about ¼ mile are terrace remnants.
0.05+	25.6+	T-road from left, Salt Spring Hollow. CONTINUE AHEAD (south) and cross a narrow bridge.
0.5+	26.15	CAUTION: right side of road for next 0.05 mile is collapsing downslope. Heavy rainfall has saturated the soil, which has slipped down across the underlying shale bedrock.
0.3+	26.45+	Good close-up view of the Mississippi Valley.
0.1	26.55+	To the left, a slump from saturated soil material has filled the ditch, so drainage is poor on the east side of the road. As a result, the blacktop is breaking up, and the roadway is slipping to the right. The Chouteau Limestone crops out some 12 feet above the road. Water percolating through its open cracks and joints has produced a line of seeps or small springs at its contact with the underlying Hannibal Shale. The water from the seeps has moved downslope beneath the detritus covering the hillside. Saturated debris near the former ditch has collapsed into and filled the ditch.
0.25+	26.85	T-road from the left just before the creek crossing. On the north side of the T-road is a loess exposure that has slumped. Because the base of the exposure was not drained properly, the loess slumped, forming some terracettes (small, steplike scarps) down the exposure. CONTINUE AHEAD (south).
0.5	27.35	CAUTION: keep to left as the right half of the road is collapsing.


Kritesville
Watson Lake
Campbells Island
Keeton Island
LINCOLN CO
CALHOUN CO
MARK TWAIN NATIONAL WILDLIFE REFUG
Franklin Hill
Franklin Hill
DIVIDING
DIVIDING
Turner Branch
BR 467
BR 532
9
0 ½ 1 mi
0 ½ 1 1½ km

0.6	27.95	Loess cut shows slumping.
0.8	28.75	CAUTION: narrow culvert is partly obscured by undergrowth.
1.0+	29.75+	T-road from the left at the mouth of Turner Hollow (1320N, 1430E). TURN LEFT (east) just before the narrow bridge.
0.3	30.05+	Limestone stream bed.
0.2	30.25+	CAUTION: cross narrow bridge across Turner Branch. Watch for Y-intersection with South Turner Hollow Road (1310N, 1480E). BEAR LEFT (northeast) on Turner Hollow Road. The surface 15 to 20 feet above us on both sides of the road is a terrace.
0.1	30.35+	CAUTION: road is washed-out on the right.
0.2	30.55+	CAUTION: narrow bridge has no railings or markings.
0.2	30.75+	CAUTION: another narrow bridge has no railings or markings. Notice that to your left across Turner Branch, the steep-faced cut in silts is underlain by alluvial gravel.
0.1	30.85+	CAUTION: narrow bridge. At the far end (north) on the right side of the bridge, the road is collapsing .
0.1	30.95+	Ascend the steep road onto the terrace, which is not quite as flat on top as it is farther down the valley.
0.1	31.05+	Start to ascend the steeper part of the hill.
0.5	31.55+	We are on one of the upland spurs between steep, narrow drainage lines. The ridges here are more narrow and sinuous than farther north.
0.2	31.75+	Y-intersection with Hill Top Drive (1430N, 1560E). BEAR RIGHT (east) on Turner Hollow Road.
0.1	31.85+	CAUTION: slump on the right side (inside curve) of the road.
0.15	32.0+	CAUTION: slump lies along the right side of road.
0.2+	32.25	CAUTION: another slump lies along the right side of road.
0.3	32.55	CAUTION: both sides of the roadway have partly collapsed!
0.15+	32.7+	Y-intersection with Surgeon Lane (1490N, 1600E). BEAR RIGHT (east) on Franklin Hill Road.
0.85	33.55+	CAUTION; descend steep part of Franklin Hill. Look ahead for a view of the Illinois River valley.
0.05	33.6	PARK along the road shoulder as close to the guardrail as you can safely. CAUTION: narrow road. The traffic is heavy at times. PLEASE pay attention to directions and warnings!

STOP 9 The Mississippian (Valmeyeran) Burlington and underlying (Kinderhookian) Chouteau Limestones are exposed along the north side of the Franklin Hill roadcut (north edge, NW SW SE SE Section 22, T11S, R2W, 4th P.M., Calhoun County; Nutwood 7.5-Minute Quadrangle [39090A5]).

The upper part of this exposure has the typical coarse crinoidal debris of the Burlington Limestone (fig. 23), including abundant chert lenses and beds. The Burlington also contains abundant corals and brachiopod fossils locally, but the crinoid material predominates. Although most of the crinoidal material is disarticulated, calyces to complete crowns are locally present in the Burlington. The Burlington has been the source of some great crinoid collections put together by paleontologists of this and the last century. Crinoids are so abundant that some geologists have used the characteristic forms to divide the formation into biostratigraphic zones for correlation (that is, for tracing and matching sequences of rock units) over wide areas.

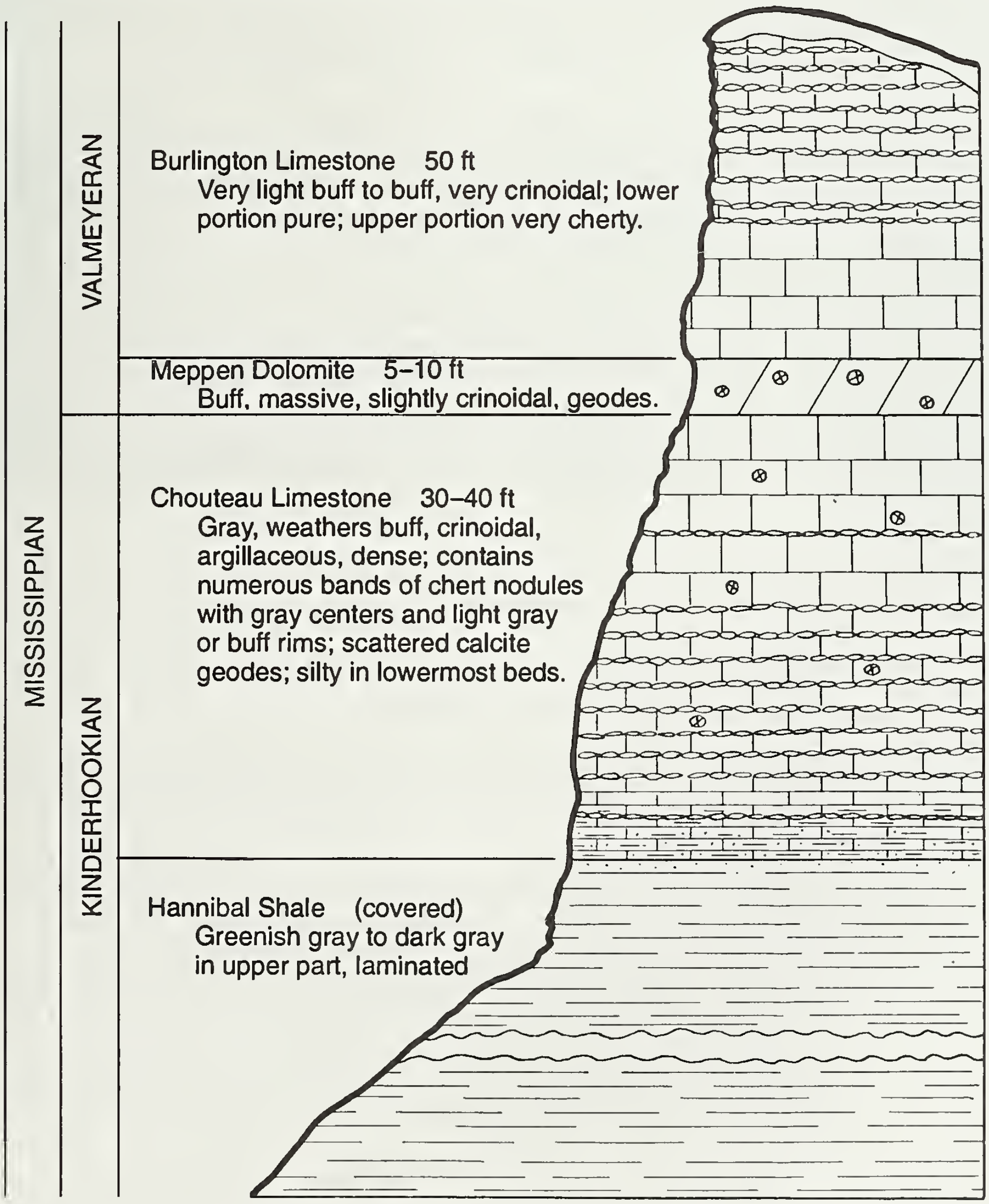


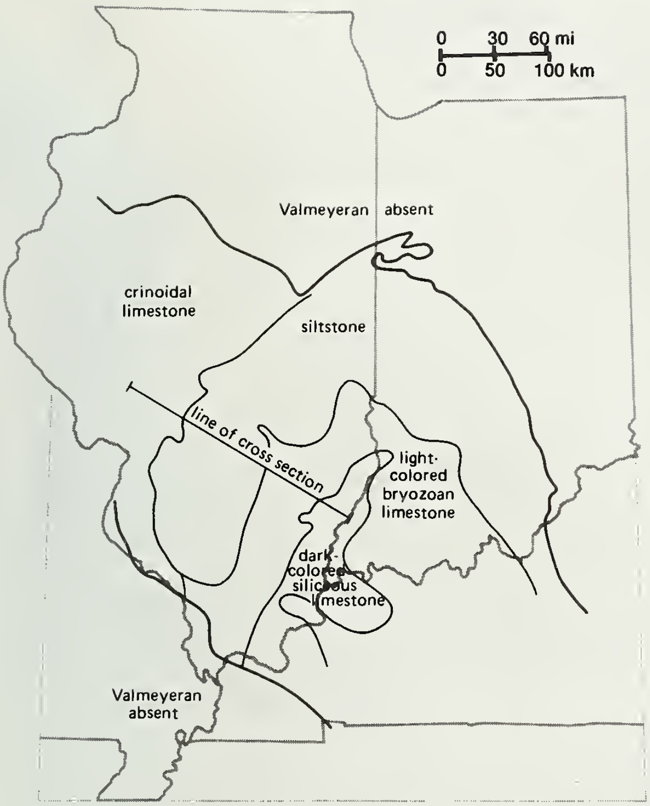
Figure 23 Generalized section of Mississippian strata exposed on the Franklin Hill roadcut.

The Burlington and the overlying Keokuk Formation (eroded here) represent a shallow water, largely clastic (fragmented), carbonate sediment (composed mainly of crinoid and other organic skeletal remains) that was deposited on the western flank of the Illinois Basin. At the same time, a delta (Borden) composed of muds, silts and sands was expanding into the basin from the northeast (fig. 24). Organic remains (primarily crinoidal, as mentioned above) were deposited by currents into underwater fossil sandbars and banks by the currents in these shallow waters. As these banks grew, they undoubtedly provided an almost "reef-like" environment in which crinoids and other marine-shelled organisms could thrive, adding to the development of the "reef." The shallow water environment was also largely free of noncarbonate sediments, which accumulated mainly to the east in the Borden Delta. Crinoids, one of the primary constituents of the Burlington carbonates,are filter feeders and quite sensitive to an increase in muds, sands, and silts such as those found in a delta.

The coarse crinoidal Burlington Limestone is the most prominent formation in the bluffs of this area. It forms the brow of cliffs for more than 50 miles along the Illinois River Valley. In Calhoun County, it forms the divide between the Illinois and Mississippi Rivers.

Downward the Burlington Limestone loses the lenses and beds of chert but remains primarily a limestone composed of coarse crinoidal debris. Near the base of the Burlington at this exposure, we find a tan, massive, somewhat dolomitic limestone that is slightly crinoidal and has scattered calcite-filled vugs up to 2 inches or so in diameter. This unit has been named the Meppen Formation by geologists who study the Mississippian rocks in Illinois. It rests unconformably on the top of the Chouteau Limestone and contains a number of solution cavities at this contact. The underlying gray to tan Chouteau Limestone contains crinoidal debris; it is shaley with zones of interlaminated calcareous siltstone or silty limestone. Like the overlying Burlington, it contains numerous bands and lenses of chert nodules with gray centers and light gray to tan rims. The siltstone increases in abundance near the base of this unit. The Chouteau also contains scattered calcite geodes like those found in the overlying Meppen Formation. The underlying Hannibal Shale is not visible at this roadcut because blocks and debris have slumped from the overlying, weathered Chouteau Limestone.

0.0	33.6	Leave Stop 9 and CONTINUE AHEAD (east) downhill with caution!
0.25+	33.85+	CAUTION: the road has eroded around tile under the road near base of hill. Do NOT let a wheel drop into the hole!
0.15	34.0+	STOP: 1-way at T-intersection with Illinois River Road (1520N, 1720E). TURN LEFT (north). Note cliff of Burlington Limestone at about 11 o'clock after you turn.
0.35	34.35+	View to the left at about half-past 10 o'clock is a "half dome" that has been bisected by the lateral cutting of the valley now occupied by the Illinois River. The topography of the area away from the rivers probably developed early during the Pleistocene. So the valley widening that produced the "half dome" took place later. The most likely time of this widening was during the late Wisconsinan when enormous volumes of meltwater were coursing down the valley.
1.75	36.1+	Lead Hollow Road to left. CONTINUE AHEAD (north). The base of the bluff shows exposures of Silurian strata.



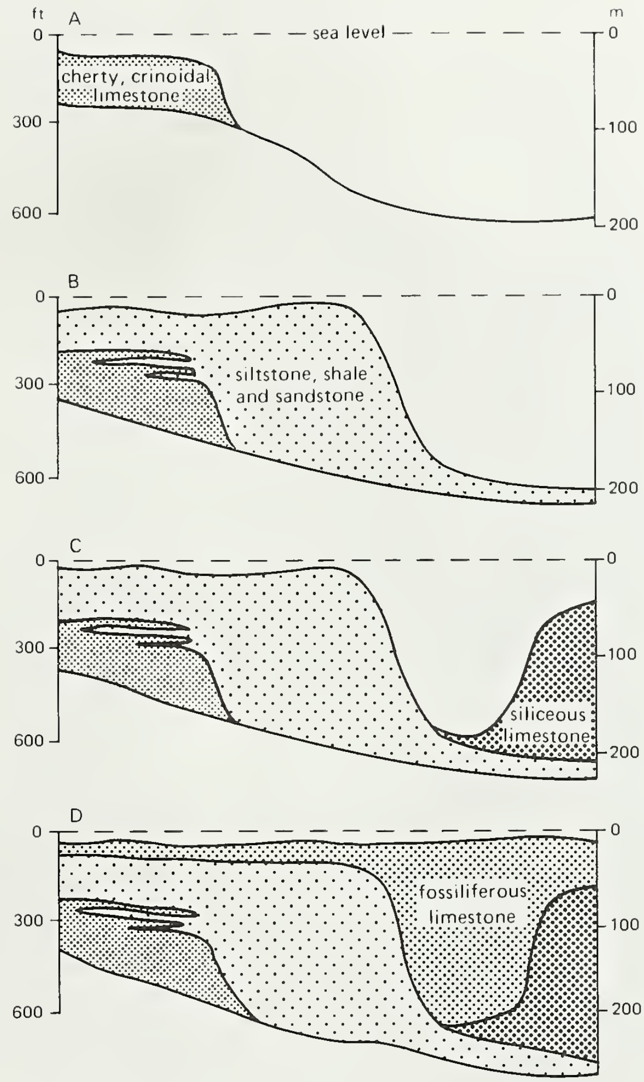
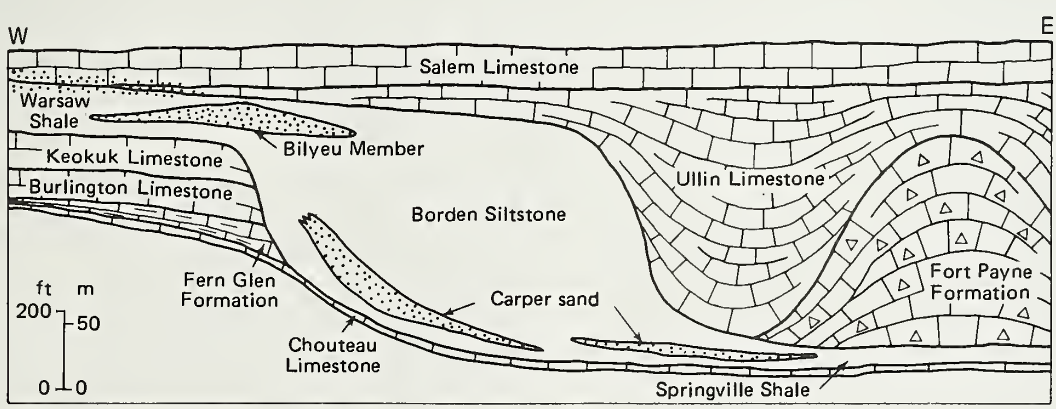
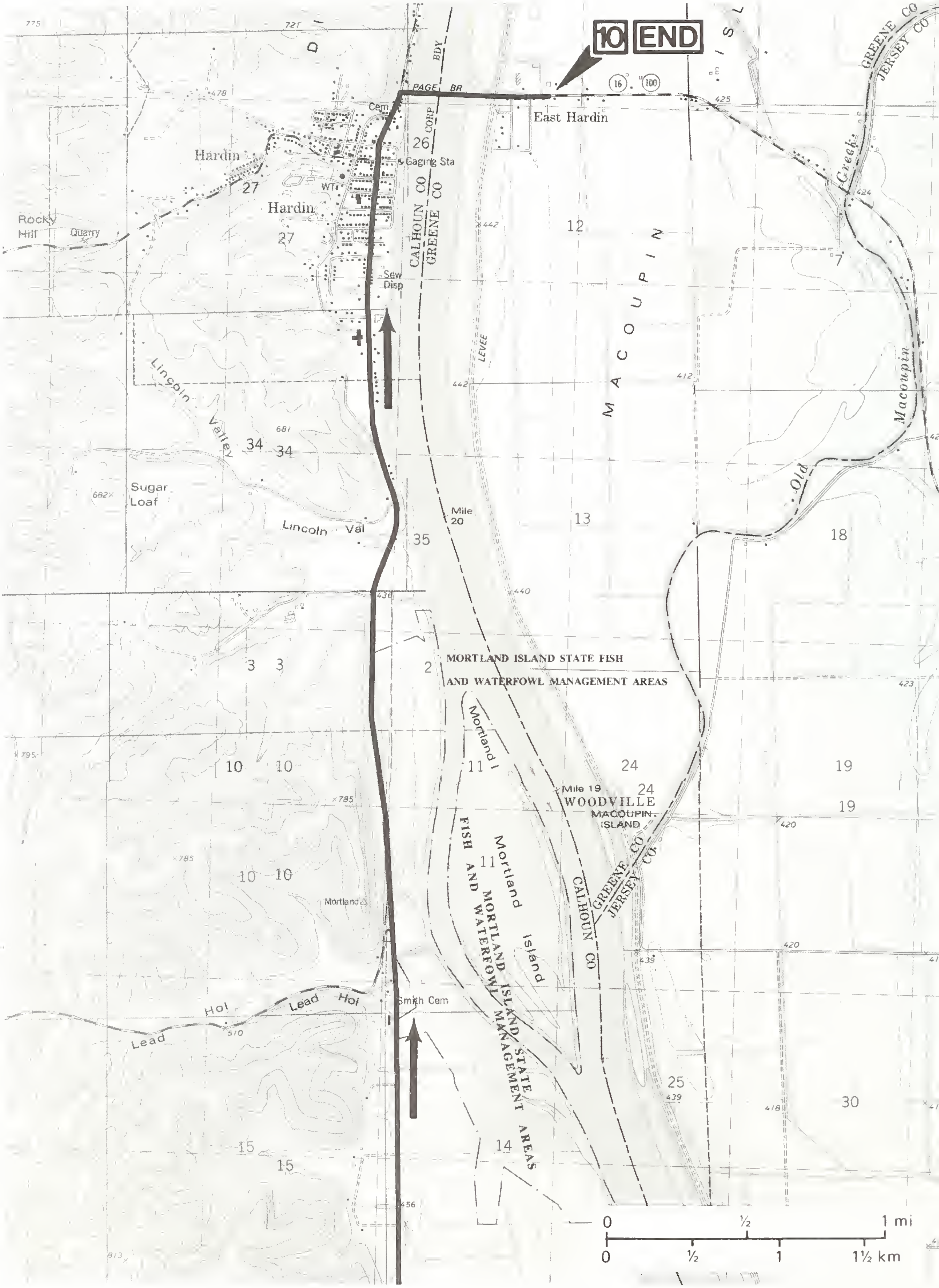


Figure 24 Areal distribution (above) and stages (right) of sedimentation resulting in observable rock stratigraphic relationships (below) in early Valmeyeran time (after Lineback 1966, 1968, and 1969).





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0.3	36.4+	The "dead line" on the trees to the right resulted from the 1993 flooding. You will also note a water line or wave-cut bank to the left on the hillslope at the same elevation, approximately 440 feet msl at flood crest (within the Nutwood drainage district just across the river to the east).
1.65	38.05+	CAUTION: enter town of Hardin.
0.75+	38.85	STOP: 4-way at Main Street. CONTINUE AHEAD (north) on Park Street.
0.25	39.1	CAUTION: junction with routes 16/100. TURN RIGHT (east) onto Page Bridge across the Illinois River.
0.1+	39.2+	Enter Greene County at mid-span on the bridge.
0.2	39.4+	Cross the Nutwood levee while on the bridge over the east side of the river.
0.2	39.6+	PARK on the road shoulder as far off the highway as you can safely. CAUTION: watch for traffic. Do NOT enter any of the properties that you see!

STOP 10 *The Great Flood of 1993* left its mark on East Hardin. We'll observe and discuss the flood damage (SW SW SW SE Section 1, T8N, R14W, 3rd P.M., Greene County; Hardin 7.5-Minute Quadrangle [39090B5]).

As the flood of 1993 progressed, the western approach to the Illinois highway 16/100 bridge across the Illinois River (on the Hardin side) became flooded; but the community of East Hardin on the Illinois River floodplain east of the river was protected through mid-July by the Nutwood levee. Morris W. Leighton, Chief of the Illinois State Geological Survey (ISGS), and Michael J. Chrzastowski, head of the ISGS Lakes, Streams, and Wetlands Section, visited the area on July 17, 1993. Chrzastowski reported that an area just inside the levee on the north side of the bridge was the staging area for filling sandbags. (You can still see some sandbags piled under the bridge.) It was so hot that people worked under the bridge to get out of the direct heat and light of the sun. Along the top of the levee to the south of the bridge, sandbags were piled three layers high to try to defend the community from the predicted flood crest, but there was not enough time to build up similar layers to the north. The next day, July 18, the levee was overtopped about 6 miles south of this location. Floodwater inundated the entire Nutwood Drainage and Levee District and destroyed East Hardin. Even if the levee had not failed at that point, it would still have been overtopped somewhere in this area. The height of the flood, 15 to 20 feet here, left a mark on many of the buildings and storage tanks in the town. Most of these show multiple levels of still-stands of the receding flood waters, as have many other buildings along the field trip route.

Continuing east from this stop, you can see a warehouse collapsed on the north side of the highway. Not all the damage here was caused by the flood. An initial collapse under the weight of the water left several parts of the building extremely unsafe as the flood waters waned, and the rest of the building was deliberately collapsed for safety's sake. Farther along on the north side is a house that partly floated off its foundation. To the south and closer to the levee, although not so visible from the highway, is a house that floated completely off its foundation. It was probably lifted buoyantly, then moved to its present resting place a few feet west of its foundation. We often think of a flood as simply rising water, but these buildings are ample evidence of the power of *moving* flood water.

Continuing eastward along the highway, we come to a used auto parts lot where a photo was taken of a 1951 Nash automobile perched high on a post—one of the pictures seen nationwide in stories on the flood. The flood waters came up to the wheels of this car, according to school

superintendent, Terry Strauch. Although cars have been added to the lot since the flood, many are still covered with the oily silty film left from the flood.

Numerous areas on the floodplain and along the bluffs that are not on the field trip route clearly illustrate the processes of erosion and deposition that take place during a major flood. But in this area, very little sediment was deposited. After the flood waters receded, field observers documented that within flooded drainage and levee districts, sediment would be deposited for about 1 mile or so away from the levee breach. Elsewhere across the district, the flood waters typically carried little if any sediment.

END OF FIELD TRIP

Have a safe journey home and join us next fall for more field trips!

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GLOSSARY

The following definitions are from several sources, in total or in part, but the main reference is *Glossary of Geology* (third edition) by Robert L. Bates and Julie A. Jackson (American Geological Institute 1987).

Accretion —The process by which an inorganic body increases in size by the external addition of fresh particles, as by adhesion.

Age — An interval of geologic time; a division of an epoch.

Alluviated valley — A valley that has been at least partially filled with sand, silt, and mud by flowing water.

Alluvium —A general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during comparatively recent time by a stream or other body of running water as a sorted or semisorted sediment in the bed of a stream or on its floodplain or delta, etc.

Anticline — A convex upward rock fold in which strata have been bent into an arch; the strata on each side of the core of the arch are inclined in opposite directions away from the axis or crest; the core contains older rocks than does the perimeter of the structure.

Aquifer — A water-bearing geologic unit that will yield a usable quantity of water to a well or spring.

Arenite — (1) Consolidated sedimentary rocks composed of sand-sized fragments regardless of composition; (2) a nearly pure sandstone containing less than 10% argillaceous matrix; (3) a selectively and slowly deposited sediment well-washed by currents.

Argillaceous — largely composed of clay-sized particles or clay minerals.

Argillic — of or relating to clay minerals.

Base level — The lowest limit of subaerial erosion by running water. It is controlled locally and temporarily by the water level where streams enter lakes or, more generally and semipermanently, where they enter the ocean (mean sea level).

Basement complex —Largely crystalline igneous and/or metamorphic rocks, often having a complex structure and distribution, that underlie a sedimentary sequence.

Bed — A naturally occurring layer of Earth material of relatively greater horizontal than vertical extent that is characterized by physical properties that are distinctively different from those of the overlying and underlying materials. A *bed* also is the surface upon which any body of water rests or has rested, or the surface covered by the waters of a stream, lake, or ocean; the bottom of a watercourse or of a stream channel.

Bedded — Formed, arranged, or deposited in layers or beds, or made up of or occurring in the form of beds.

Bedding — The arrangement of a sedimentary rock in beds or layers of varying thickness and character.

Bedding plane — A planar or nearly planar surface, either between beds or within a bed, that visibly separates successive layers of stratified rock (of the same or different lithology) from preceding or following layers; a plane of deposition. It is often characterized by a preferred plane of breakage and may mark changes in the circumstances of deposition.

Bedrock — The solid rock that underlies the unconsolidated (non-indurated) surface materials, such as soil, alluvium, glacial drift or loess.

Bedrock valley — A drainageway eroded into the solid bedrock beneath the surface materials. It may be completely filled with unconsolidated (non-indurated) materials and hidden from view.

Bioturbation — the churning and stirring of a sediment by organisms.

Brackish — Water that is noticeably salty, but less salty than sea water.

Braided stream — A stream that flows through an intricate network of interlacing shallow channels that repeatedly merge and then divide again separated from each other by branch islands or channel bars. Such a stream is generally believed to indicate an inability to carry all of its load. Braiding commonly develops in streams subject to large fluctuations in flow volume.

Breccia — A clastic rock composed of coarse, angular rock fragments.

Calcareous — Containing calcium carbonate ($CaCO_3$); limy.

Calcarenite — Limestone composed of sand-sized grains consisting of more or less worn shell fragments or pieces of older limestone; a clastic limestone.

Calcite — A common rock-forming mineral with the chemical composition $CaCO_3$ (calcium carbonate). It is usually white, colorless, or pale shades of gray, yellow, and blue; has perfect rhombohedral cleavage; a vitreous luster, and a Moh's hardness of 3. Calcite effervesces (fizzes) readily in cold dilute hydrochloric acid. It is the principal constituent of limestone.

Carbonization — The process of concentrating residual carbon through the slow decay and fossilization of an organism or through the progressive changes that occur in the formation of coal.

Chalcedony — A "cryptocrystalline " variety of the mineral quartz (silicon dioxide; SiO_2). It commonly consists of a mass of submicroscopic crystallites that appear fibrous under a microscope. Chalcedony may be translucent or semitransparent, has a nearly wax-like luster, a uniform tint, and may be white, pale-blue, gray, brown, or black in color. It has no defined habit and commonly occurs in lumpy nodules (cf. chert; geodes).

Chert — A compact, massive rock composed of minute particles of quartz and/or chalcedony (silicon dioxide; SiO_2). It often occurs as irregular nodules and thin layers in limestone and dolomite. Flint is the name applied to chert that is dark in color.

Clastic — (adj.) Composed of detritus derived from broken fragments of preexisting rocks, including fragments of the hard parts of organisms.

Closure — In a fold, dome or other structural trap, the vertical distance between the structure's highest elevation and the lowest contour that encloses itself; used in estimating petroleum reserves.

Columnar section — A graphic representation in a vertical column of the sequence and original stratigraphic relations of the rock units in a region.

Conchoidal — (adj.) A fracture surface showing concentric rings or ridges in a shell-like or fan-shaped plan. The conchoidal fracture of flint and chert is the property exploited in making sharp stone tools.

Concretion — A localized accumulation of mineral matter in a spheroidal to irregular nodular mass.

Conglomerate — Lithified gravel; rounded pebbles cemented together.

Cryptocrystalline — (adj.) Exceedingly finely crystalline in texture and appearance with grains essentially indistinguishable even under an ordinary microscope.

Cuesta — An asymmetric hill or ridge with a long, gentle (back or dip) slope, conforming with the resistant bed(s) that form it, on one side and a steep (scarp) slope or cliff on the other, formed by the outcrop of the resistant bed(s).

Delta — A low, nearly flat, alluvial land deposited at or near the mouth of a river where it enters a body of standing water; commonly a triangular or fan-shaped plain sometimes extending beyond the general trend of the coastline. Named for its resemblance to the Greek letter (delta).

Desiccation crack — A crack in sediment produced by drying (e.g., a mud crack).

Detritus — Loose rock or mineral grains produced from older rocks by mechanical disintegration and abrasion.

Diamictite — A comprehensive, nongenetic term for a nonsorted or poorly sorted, noncalcareous, terrigenous sedimentary rock that contains a wide range of particle sizes, such as a rock consisting of sand-size and/or larger particles in a muddy matrix; e.g. a tillite or a pebbly mudstone.

Diamicton — A general term for the nonlithified equivalent of a diamictite; e.g. a till. A till is a diamicton formed by the action of a glacier. The term *till* has a genetic connotation; diamicton does not, it is purely descriptive.

Diastrophism — A general term for all movement of the crust produced by Earth's forces.

Dike — A tabular, intrusive body of igneous rock that cuts across the structure of stratified, metamorphosed, or igneous rocks.

Dip slope — An inclined land surface that is parallel to the dip of the underlying stratified rocks.

Disconformity — An *unconformity* marked by a distinct, erosion-produced irregular, uneven surface of appreciable relief between parallel strata below and above the break; sometimes represents a considerable interval of nondeposition.

Distributary — An irregular, divergent stream flowing away from the main stream and not returning to it, as in a delta.

Doline — A closed depression in an area of karst topography that is formed either by solution of the surficial limestone or by collapse of underlying caves. Its form generally is basin-like or funnel-shaped and measured in meters.

Dolomite — A mineral, calcium-magnesium carbonate [$Ca,Mg(CO_3)_2$]. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; effervesces feebly in cold dilute hydrochloric acid. The term is also commonly applied to those sedimentary rocks that are composed largely (more than 50%) of the mineral dolomite.

Dolostone — A rock consisting mostly (more than 50%) of the mineral dolomite. This word is sometimes used when there is a possibility of confusion in using the term *dolomite* for both the rock and the mineral.

Dome — A roughly symmetrical upfold (anticline) in which strata are inclined in all directions away from a central point.

Drift — All rock material transported by a glacier and deposited either directly by the ice or reworked and deposited by meltwater streams and/or the wind.

Driftless Area — A 10,000 square mile area in northeastern Iowa, southwestern Wisconsin, and northwestern Illinois where the absence of glacial drift suggests that the area may not have been glaciated during the Pleistocene.

Earthquake — A sudden motion or trembling in the Earth caused by the abrupt release of slowly accumulated potential energy (like that in a compressed spring) through the breaking of a rock body to form a fault, or slippage along a preexisting fault plane in the rock body.

End moraine — A ridge-like or series of ridge-like accumulations of drift built along the margin of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier. (syn. *terminal moraine*)

Englacial — (adj.) Within a glacier.

Eon — The largest division of geologic time; consists of two or more eras.

Epeirogeny — A form of diastrophism which has produce the larger features of the continents and oceans. These movements are primarily vertical and have affected large parts of the continents where they have produced most of the present mountainous topography. Some epeirogenic orogenic structures grade into each other in detail, but most of them contrast strongly.

Epoch — An interval of geologic time; a division of a period.

Era — A unit of geologic time that is next in magnitude beneath an eon; consists of two or more periods (e.g. Paleozoic, Mesozoic, Cenozoic).

Esker — Ridges, usually sinuous, of stratified (layered) drift (sand and gravel) in areas of ground moraine. They are deposited by, and mark the channels of, meltwater streams which flowed in, on, or under a glacier.

Estuary — The seaward end or the widened funnel-shaped tidal mouth of a river valley where it meets the sea. The part of a river where freshwater and seawater mix and where the effects of ocean tides are evident.

Facies — (1) The sum of all lithologic and paleontologic characteristics exhibited by a sedimentary rock; (2) an exclusive, mappable, and areally restricted part of a defined stratigraphic rock body; (3) a term applied to intertonguing sedimentary rock masses of differing lithologic and paleontologic characteristics, occurring within a stratigraphic unit, having irregular boundaries. The term is often used by geologists in a general sense to refer to all rocks having a common set of lithologic characteristics, or to rocks formed in a particular environment and, therefore, having a set of characteristics in common.

Fault — A fracture surface or zone in Earth materials along which there has been vertical and/or horizontal displacement or movement of the strata on both sides relative to one another. The amount of displacement may be as little as a few centimeters to as much as many kilometers.

Feldspar — Any of several abundant rock-forming minerals of the general chemical composition alkali-metal alumino-silicate [$MAl(Al,Si)_3O_8$; where M = K, Na, Ca, Ba, Rb, Sr and Fe]. They have a hardness of 6 on Moh's scale. Their normal color is translucent white or near-white, but they are commonly colored by impurities. The potash feldspars are commonly flesh-colored to red. Feldspars are the most widespread of any mineral group; they constitute about 60% of the Earth's crust. They are the primary constituents of most igneous and metamorphic rocks and are present in many sedimentary rocks. There are two major types of feldspars, the alkali or potash feldspars (e.g. orthoclase and microcline) which have potassium and sodium as their main alkali metal cations, and the plagioclase feldspars (e.g. albite, andesine, labradorite) which have sodium and calcium as their main alkali metal cations. The word feldspar is from German and means *field crystal.*

Feldspathic — (adj.) Said of a rock containing an observable quantity of feldspar, but consisting mostly of other components. Rocks that normally consist mostly of feldspar generally are not described as "feldspathic."

Ferruginous — (adj.) Pertaining to or containing iron, e.g. a sandstone that is cemented with iron oxide.

Floodplain — The surface or strip of relatively smooth land adjacent to a stream channel that has been produced by the stream's erosion and deposition actions; the area covered with water when the stream overflows its banks at times of high water. It is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.

Fluvial — (adj.) Of or pertaining to a river or rivers.

Fluviolacustrine — (adj.) Pertains to sedimentation partly in lake water and partly in streams, or to sediments deposited under alternating or overlapping lacustrine and fluvial conditions.

Formation — The basic rock unit distinctive enough to be readily recognizable in the field and widespread and thick enough to be plotted on a map. It describes the strata, such as limestone, sandstone, shale, or combinations of these and other rock types; formations have formal names, such as Joliet Formation or St. Louis Limestone (Formation), usually derived from geographic localities.

Geology — (a) The science of the earth; it includes, in a large sense, all acquired or possible knowledge of the natural phenomena on and within the globe. (b) Earth science including physical geology and geophysics; the history of the earth, stratigraphy and paleontology; mineralogy; petrology; and engineering, mining, and petroleum geology.

Geomorphology — A branch of both physiography and geology that deals with the form of the earth, the general configuration of its surface, and the changes that take place in the evolution of land forms.

Geophysics — The study of the Earth as a planet, generally by employing quantitative measurements of phenomena such as the Earth's electrical, magnetic and gravity fields or the movement of energy through the rocks.

Glacier — A large, slow-moving mass of ice grounded, at least in part, on land. The Arctic ice cap of the Earth is NOT a glacier because, for the most part, it is floating on the ocean surface. The Antarctic ice cap IS a glacier

Graben — A block that has moved down along bounding faults relative to the rocks on either side.

Gradient — A measurement of the degree of inclination or rate of ascent or descent of an inclined part of the Earth's surface with respect to the horizontal; commonly expressed as a ratio (ft/mi; m/km). Also, the part of a surface feature of the Earth that slopes upward or downward; a slope, as of a stream channel or of a land surface. In engineering, the synonymous term is *grade.*

Ground moraine — A sheet-like accumulation of glacial drift, principally till, deposited beneath a glacier to form an extensive area of low relief devoid of transverse linear features.

Groundwater — Water that is present below the ground surface in the soil and rocks of Earth's outer crust. Geologists generally restrict the term to that part of the subsurface water that is within the zone where the rocks are saturated with water (i.e., below the water table). Also commonly spelled as *ground water.*

Group — A geologic rock unit consisting of two or more formations.

Gypsum — A mineral having the composition hydrous calcium sulfate {$CaSO_4 2H_2O$}; it is characteristically white or colorless when pure. The most common sulfate mineral, it generally occurs in thick, extensive beds formed by the evaporation of large quantities of seawater.

Hematite — A common iron mineral having the composition ferrous oxide {Fe_2O_3}. The principal ore for iron, the mineral occurs in steel-gray or iron-black rhombohedral crystals, in globular and fibrous masses and, most commonly, in deep red to red-brown earthy forms. It has a characteristic brick red color when powdered.

Hiatus — A gap in the sedimentary record, with or without accompanying removal of sediment by erosion (signifies an unconformity).

Ice cap — A dome-shaped or plate-like cover of perennial ice and snow, covering the summit area of a mountain mass so that no peaks emerge through it, or covering a flat landmass such as an Arctic island...and having an area less than 50,000 sq. km.; it is considerably smaller than an *ice sheet.*

Ice sheet — A glacier of considerable thickness and more than 50,000 sq. km. in area, forming a continuous cover of ice and snow over a land surface spreading outward in all directions and not confined by the underlying topography; a *continental glacier.*

Igneous — (adj.) Said of a rock or mineral that has solidified from molten or partly molten material, i.e., from magma.

Indurated — (adj.) Said of a compacted rock or soil hardened by the action of pressure, cementation, and especially heat.

Joint — A fracture or crack in rocks along which there has been no significant relative movement of the rock masses on opposing sides of the crack.

Kame — A hill, mound, knob or hummock formed of poorly sorted and stratified sand and/or gravel deposited against the terminal margin of a melting glacier by a subglacial or englacial melt water stream.

Karst — A type of topography formed in areas underlain by limestone, dolomite or gypsum. Karst topography is characterized by sinkholes separated by steep ridges or irregular hills. Tunnels and caves resulting from solution by groundwater honeycomb the subsurface. Named for the Karst region of the Dinaric alps in Yugoslavia where the topography is especially well developed. (Adj.) karstic.

Karstification — The formation of the features of a karstic topography by solutional, and sometimes mechanical, action of water in a region of limestone, dolomite, or gypsum bedrock.

Lacustrine — (adj.) Produced by or belonging to a lake.

Laurasia — A combination of Laurentia, a paleogeographic term for the Canadian Shield and its surroundings, and Eurasia. It is the protocontinent of the Northern Hemisphere, corresponding to Gondwana in the Southern Hemisphere, from which the present continents of the Northern Hemisphere have been derived by separation and continental displacement. The hypothetical supercontinent from which both were derived is Pangea. The Laurasian protocontinent included most of North America, Greenland, and most of Eurasia, excluding India. The main zone of separation was in the North Atlantic, with a branch in Hudson Bay, and geologic features on opposite sides of these zones are very similar.

Lava — A general term for molten material extruded onto the Earth's surface from a volcano; also, applies to the rock that solidified from the extruded material.

Limestone — A sedimentary rock consisting primarily (more than 50%) of calcium carbonate $CaCO_3$ (the mineral, calcite). Most limestones were deposited in the ocean and consist primarily of fragments of the hard parts of living organisms.

Litharenite — A sandstone, regardless of texture, containing more than 25% fine grained rock fragments, less than 10% of the feldspar minerals, and less than 75% quartz, quartzite, and chert.

Lithify — (v.) To change to stone, or to petrify; esp. to consolidate from a loose sediment to a solid rock.

Lithology — The description of a rock on the basis of its color, particle size, mineral composition, bedding and other directly observable characteristics; the physical character of a rock.

Local relief — The vertical difference in elevation between the highest and lowest points of a land surface within a specified horizontal distance or within a limited area.

Loess — A homogeneous, unstratified deposit of silt deposited by the wind.

Magma — Naturally occurring mobile rock material, generated within Earth and capable of intrusion and extrusion, from which igneous rocks are thought to have been derived through solidification and related processes.

Marble — Metamorphosed limestone or dolostone generally with a more or less coarse grained crystalline texture.

Meander — One of a series of somewhat regular, sharp, sinuous curves, bends, loops, or turns produced by a stream, particularly in its lower course where its channel swings from side to side across its valley bottom.

Meander scars — Crescent-shaped, concave marks along a river's floodplain that mark the positions of abandoned meanders. Although generally filled in with sediments and vegetation, they are generally low swales and may contain water during wet seasons. Often invisible from the ground, they make striking patterns when viewed from the air, and may also be readily apparent on topographic maps.

Metamorphic rock — Any rock derived from pre-existing rocks through mineralogical and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in Earth's crust (e.g. gneiss, schist, slate, marble, quartzite, etc.).

Metamorphism — The processes by which metamorphic rocks are formed and the changes in a preexisting rock induced by those processes. In general, metamorphism does not alter the chemical composition of the preexisiting rock. The processes only rearrange the preexisting chemical elements in the rock from one set of minerals to a new set of minerals more closely in equilibrium with the new temperature and pressure conditions imposed on the rock.

Mica — Any of the members of a group of minerals known as phyllosilicates (having sheet-like structures) that can be easily split apart into thin, tough, slightly bendable sheets. The micas are common minerals in igneous and metamorphic rocks and can range in color from colorless through yellow, green, brown or black. The most common members of the family are muscovite (colorless to pale yellow) and biotite (dark brown to black).

Micaceous — (adj.) Said of an Earth material containing an observable amount of mica.

Monocline — Strata inclined in a single direction, such as a step-like fold or downwarp.

Moraine — A mound, ridge, or other distinct accumulation of glacial drift, predominantly till, deposited chiefly by the direct action of glacial ice in a variety of topographic landforms whose position and shape are not affected by the topography of the former land surface on which the drift lies.

Morphology — The scientific study of form, and of the structures and development that influence form; term used in most sciences.

Neap tide — A tide having an unusually small or reduced tide range (usually 10-30% less than the mean range). Such tides occur when the Moon and Sun are at right angles to each other with respect to the Earth (quadrature).

Nonconformity — An unconformity resulting from the deposition of sedimentary strata on top of older crystalline rocks that have been exposed to weathering and erosion. The general term *unconformity* is currently used more commonly.

Normal fault — A fault in which the hanging wall (the rock mass above the fault plane) has moved downward relative to the foot wall (the rock mass below the fault plane).

Oolith — A small round or ovate accretionary body in a sedimentary rock, resembling fish eggs, and having diameters of 0.25 to 2 mm. It is usually composed of calcium carbonate and occurs in successive concentric layers, commonly around a nucleus such as a shell fragment.

Oolitic — Pertaining to an oolite (a rock or mineral made up of ooliths).

Orogeny — Literally, the process of mountain formation. By present geological usage it is the process by which structures within mountain areas were formed, including thrusting, folding, and faulting in the upper and higher layer of the Earth's crust, and plastic folding, metamorphism, and plutonism in the inner and deeper layers.

Outwash — Stratified detritus (gravel, sand, silt and clay) that was "washed out" from a glacier by meltwater streams and deposited in channels, deltas, outwash plains, floodplains, and lakes in front of (beyond) the terminal moraine or the margin of an active glacier.

Outwash plain — The surface formed by a broad body of outwash deposited in front of a glacier.

Overburden — Barren rock material, either loose or consolidated, overlying a mineral deposit, which must be removed prior to mining.

Oxbow lake — A crescent-shaped lake in an abandoned meander of a river channel.

Paleosol — A buried soil horizon of the geologic past. When uncovered, it is said to be exhumed. (Syn.: buried soil; fossil soil).

Pangea — A hypothetical supercontinent; supposed by many geologists to have existed at an early time in the geologic past, and to have combined all the continental crust of the Earth, from which the present continents were derived by fragmentation and movement away from each other by means of some form of continental displacement. During an intermediate stage of the fragmentation, between the existence of Pangea and that of the present widely separated continents, Pangea was supposed to have split into two large fragments, *Laurasia* on the north and *Gondwana* on the south. The proto-ocean around Pangea has been termed *Panthalassa*. Other geologists, while believing in the former existence of Laurasia and Gondwana, are reluctant to concede the existence of an original Pangea; in fact, the early (Paleozoic or older) history of continental displacement remains largely undeciphered.

Peneplain — A land surface of regional proportions worn down by erosion to a nearly flat or broadly undulating plain.

Period — An interval of geologic time; a division of an era (e.g. Cambrian, Jurassic, Tertiary).

Phreatic water — A term applied to all water in the zone of saturation.

Plutonic — Pertaining to igneous rocks formed at great depth.

Physiography — The study and classification of the surface features of Earth on the basis of similarities in geologic structure and the history of geologic changes.

Physiographic province (or division) — (a) A region, all parts of which are similar in geologic structure and climate and which has consequently had a unified geologic history; (b) a region whose pattern of relief features or landforms differs significantly from that of adjacent regions.

Polycheate worms — A class of annelid (segmented) marine worms common to seacoasts where some live in U-shaped tubes in beach sands; its chitinous jaws may be preserved in many systems of rocks from ?Precambrian to Recent.

Proglacial — (adj.) In front of a glacier.

Prograding (shoreline) — A shoreline that is being built forward or outward into a sea or lake by deposition and accumulation of sediments.

Quartz — An important rock-forming mineral having the chemical composition silicon dioxide (SiO_2). It is second only to feldspar in abundance in the Earth's crust. It occurs in either colorless and transparent hexagonal crystals (sometimes colored pink, yellow, brown, purple, red, green, blue, or black by impurities) or in crystalline or cryptocrystalline masses; it forms the major portion of most sands, and is widely distributed in igneous, metamorphic, and sedimentary rocks. It appears vitreous to greasy, has a conchoidal fracture, no cleavage, and a hardness of 7 on Moh's scale (scratches glass easily, but cannot be scratched by a knife).

Relief — (a) A term used loosely for the actual physical shape, configuration, or general unevenness of a part of Earth's surface, considered with reference to variations of height and slope or to irregularities of the land surface; the elevations or differences in elevation, considered collectively, of a land surface (frequently confused with topography). (b) The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given region; "high relief" has great variation; "low relief" has little variation.

Residuum — An accumulation of relatively insoluble materials and weathering products remaining essentially in place after the more soluble materials have been removed.

Sediment — Solid, fragmental material, either inorganic or organic, that originates from the weathering of rocks and is transported by, suspended in, or deposited by air, water, or ice, or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms, and that forms in layers on Earth's surface at ordinary temperatures in a loose, unconsolidated form; e.g, sand, gravel, silt, mud, till, loess, alluvium.

Sedimentary rock — A rock resulting from the compaction, consolidation and cementation of loose sediment. The term also includes evaporites, rocks such as gypsum or rock salt formed by the evaporation of sea water.

Series — A geologic time–rock unit; the strata deposited during an epoch; a division of a system (e.g. the Chesterian Series and the Valmeyeran Series of the Mississippian System).

Sill — A tabular, intrusive body of igneous rock that conforms with the structure of the stratified sedimentary, metamorphic, or igneous rocks into which it is intruded.

Sinkhole — A circular depression formed by solution in areas underlain by soluble rocks, most commonly limestone and dolomite. Sinkholes are characteristic in areas of karst topography. They are also called *dolines*, especially outside North America.

Sluiceway — An overflow channel.

Spring tide — (a) A tide of greater-than-average range that occurs twice each month, during new and full moons, when the moon and sun are approximately in line with each other and with the Earth; (b) a strong or heavy flow.

Stage, substage — Geologic time-rock units; the strata formed during an age or subage, respectively.

Stratigraphy — (a) The branch of geology that deals with the study, definition, and description of major and minor natural divisions of rocks, especially the study of the form, arrangement, geographic distribution, chronologic succession, classification, correlation, and mutual relationships of rock strata. (b) The description of the characteristics of the stratified rocks of a region and their interrelationships and arrangement in geologic time and space within that region; sometimes called *stratigraphic geology*.

Stratigraphic unit — A stratum or body of strata recognized as a unit in the classification of the rocks of Earth's crust with respect to any specific rock character, property, or attribute or for any purpose such as description, mapping, and correlation.

Stratum, strata (pl) — A tabular or sheet-like mass, or a single and distinct layer, of homogeneous or gradational sedimentary material of any thickness, visually separable from other layers above and below by a discrete change in character of the material deposited or by a sharp physical break in deposition, or by both; a sedimentary *bed*.

Stylolite — A surface or contact, usually occurring in otherwise homogeneous carbonate rocks, that is marked by an irregular and interlocking penetration of the two sides: the columns, pits, and teeth-like projections on one side fit into their counterparts on the other. The seam is characterized by a concentration of the dark-colored, insoluble constituents of the rock and, as usually seen in cross section, it resembles a suture, or the tracing of a stylus, approximately parallel to the bedding.

Subage — An interval of geologic time; a division of an age.

Sublitharenite — A sandstone that does not have enough rock fragments to be classed as a litharenite; (5-25% fine grained rock fragments, 65-95% quartz, quartzite, and chert, and less than 10% feldspar).

Surficial — Pertaining to, situated at, or formed or occurring on a surface especially the surface of the Earth.

Syncline — A concave upward rock fold in which the rocks are bowed down and dip inward from both sides toward the axis. The core contains younger rocks than does the perimeter of the structure; the opposite of an anticline.

System — The largest and fundamental geologic time-rock unit; the strata of a system were deposited during a *period* of geologic time (e.g. the Cambrian System includes all the rocks deposited during the Cambrian Period).

Tectonic — (adj.) Pertaining to the global forces involved in mountain-building, the movement of crustal plates and the deformation or movement of other large-scale features, or the structures or features resulting from Earth's movements.

Tectonics — The branch of geology dealing with the broad architecture of the upper (outer) part of Earth's crust; a regional assembling of structural or deformational features, their origins, historical evolution, and mutual relations.

Terrigenous deposits — Shallow marine sediments consisting of material eroded from the land surface.

Till — Unconsolidated, nonsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogeneous mixture of different sizes and kinds of rock fragments. A diamicton deposited by a glacier.

Till plain — The undulating surface of low relief in the area underlain by ground moraine.

Topography — (1) The general configuration of the land surface. (2) The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.

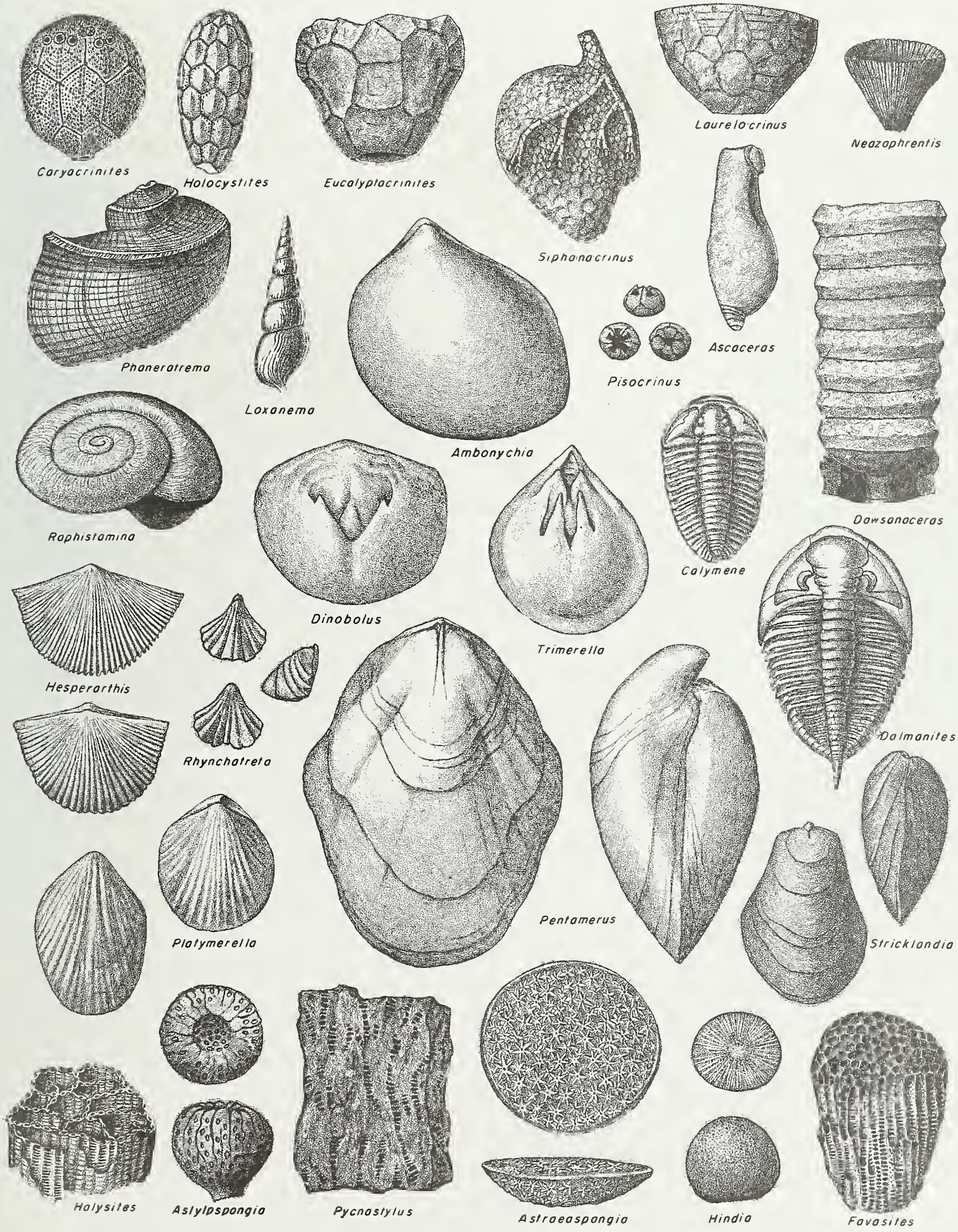
Type section — The original sequence of strata as described for a given locality or area. It serves as an objective standard with which spatially separated outcrops of a stratigraphic unit can be compared for purposes of recognition. Type sections preferably show the maximum thickness of a stratigraphic unit and are completely exposed, or at least show the top and bottom contacts of a unit; there is only <u>one</u> type section for any stratigraphic unit, but additional *reference sections* may be described.

Unconformity — A surface of erosion or nondeposition that separates younger strata from older strata; most unconformities indicate intervals of time when former areas of the sea bottom were temporarily raised above sea level.

Valley trains — The accumulations of outwash deposited by rivers in their valleys downstream from a glacier.

Vadose water — Water in the aeration zone.

REPRESENTATIVE SILURIAN FOSSILS

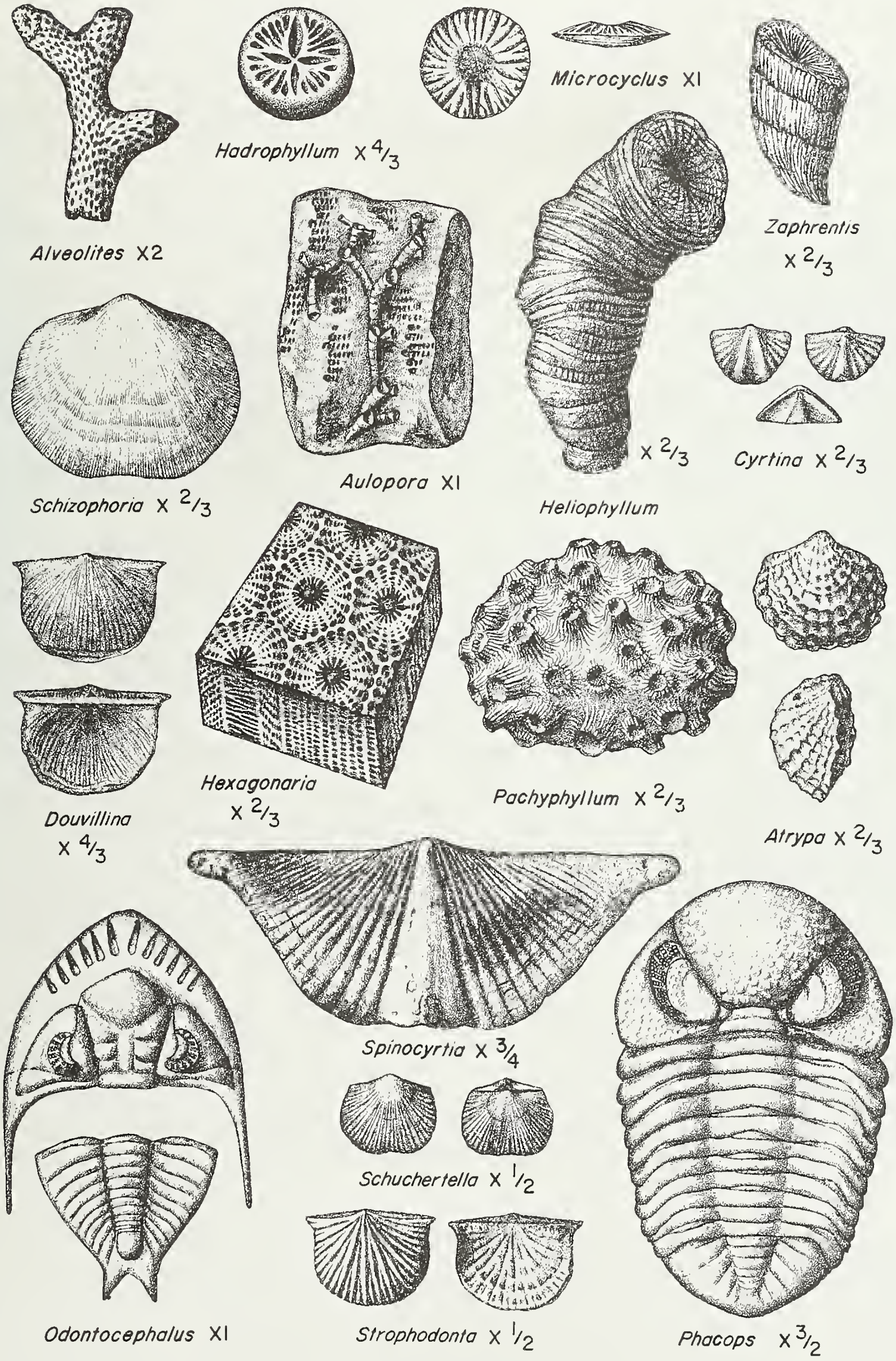


LISTING OF FOSSILS FROM SILURIAN FORMATIONS IN THE HARDIN AREA

	Kankakee	Joliet
Corals		
Zaphrentis sp.	X	
Crinoids		
stem segments	X	X
Bryozoans		
Rhionpora cf. verrucosa	X	
Brachiopods		
Atrypa sp	X	
Atrypa reticularis		X
Clorinda transversa	X	
Dalmanella sp.	X	
Dolerorthis flabellites	X	
Eospirifer radiatus		X
Hebertella sp	X	
Parmorthis elegantula	X	
Pentamerus laevis	X	
Platymerella manniensis	X	
Platystrophia daytonensis	X	
Plectambonites sp.	X	
Schuchertella sp	X	
Stricklandinia pyriformis	X	
Whitfieldella sp	X	
Bivalves (clams)		
Pterinea sp.	X	
Gastropods (snails)		
Cyclonema sp.	X	
Hormotoma tenera	X	
Platyceras cornutum	X	
Cephalopods		
Orthoceras sp.	X	X
Trilobites		
Calymene niagarensis	X	
Cyphaspis sp.	X	
Dalmanites sp.		X
Encrinurus sp.	X	
Illaenus sp.	X	X
Proetus sp.	X	

After Rubey 1952

REPRESENTATIVE DEVONIAN FOSSILS



MISSISSIPPIAN DEPOSITION

(The following quotation is from Report of Investigations 216: Classification of Genevievian and Chesterian...Rocks of Illinois [1965] by D. H. Swann, pp. 11-16. One figure and short sections of the text are omitted.)

During the Mississippian Period, the Illinois Basin was a slowly subsiding region with a vague north-south structural axis. It was flanked by structurally neutral regions to the east and west, corresponding to the present Cincinnati and Ozark Arches. These neighboring elements contributed insignificant amounts of sediment to the basin. Instead, the basin was filled by locally precipitated carbonate and by mud and sand eroded from highland areas far to the northeast in the eastern part of the Canadian Shield and perhaps the northeastward extension of the Appalachians. This sediment was brought to the Illinois region by a major river system, which it will be convenient to call the Michigan River (fig. 4) because it crossed the present state of Michigan from north to south or northeast to southwest....

The Michigan River delivered much sediment to the Illinois region during early Mississippian time. However, an advance of the sea midway in the Mississippian Period prevented sand and mud from reaching the area during deposition of the St. Louis Limestone. Genevievian time began with the lowering of sea level and the alternating deposition of shallow-water carbonate and clastic units in a pattern that persisted throughout the rest of the Mississippian. About a fourth of the fill of the basin during the late Mississippian was carbonate, another fourth was sand, and the remainder was mud carried down by the Michigan River.

Thickness, facies, and crossbedding...indicate the existence of a regional slope to the southwest, perpendicular to the prevailing north 65° west trend of the shorelines. The Illinois Basin, although developing structurally during this time, was not an embayment of the interior sea. Indeed, the mouth of the Michigan River generally extended out into the sea as a bird-foot delta, and the shoreline across the basin area may have been convex more often than concave.

....The shoreline was not static. Its position oscillated through a range of perhaps 600 to 1000 or more miles. At times it was so far south that land conditions existed throughout the present area of the Illinois Basin. At other times it was so far north that there is no suggestion of near-shore environment in the sediments still preserved. This migration of the shoreline and of the accompanying sedimentation belts determined the composition and position of Genevievian and Chesterian rock bodies.

Lateral shifts in the course of the Michigan River also influenced the placement of the rock bodies. At times the river brought its load of sediment to the eastern edge of the basin, at times to the center, and at times to the western edge. This lateral shifting occurred within a range of about 200 miles. The Cincinnati and Ozark areas did not themselves provide sediments, but, rather, the Michigan River tended to avoid those relatively positive areas in favor of the down-warped basin axis.

Sedimentation belts during this time were not symmetrical with respect to the mouth of the Michigan River. They were distorted by the position of the river relative to the Ozark and Cincinnati shoal areas, but of greater importance was sea current or drift to the northwest. This carried off most of the mud contributed by the river, narrowing the shale belt east of the river mouth and broadening it west

of the mouth. Facies and isopach maps of individual units show several times as much shale west of the locus of sand deposition as east of it. The facies maps of the entire Chesterian...show maximum sandstone deposition in a northeast-southwest belt that bisects the basin. The total thickness of limestone is greatest along the southern border of the basin and is relatively constant along that entire border. The proportion of limestone, however, is much higher at the eastern end than along the rest of the southern border, because little mud was carried southeastward against the prevailing sea current. Instead, the mud was carried to the northwest and the highest proportion of shale is found in the northwestern part of the basin.

Genevievian and Chesterian seas generally extended from the Illinois Basin eastward across the Cincinnati Shoal area and the Appalachian Basin. Little terrigeneous sediment reached the Cincinnati Shoal area from either the west or the east, and the section consists of thin limestone units representing all or most of the major cycles. The proportion of inorganically precipitated limestone is relatively high and the waters over the shoal area were commonly hypersaline... Erosion of the shoal area at times is indicated by the presence of conodonts eroded from the St. Louis Limestone and redeposited in the lower part of the Gasper Limestone at the southeast corner of the Illinois Basin...

The shoal area included regions somewhat east of the present Cincinnati axis and extended from Ohio, and probably southeastern Indiana, through central and east-central Kentucky and Tennessee into Alabama....

Toward the west, the seaway was commonly continuous between the Illinois Basin and central Iowa, although only the record of Genevievian and earliest Chesterian is still preserved. The seas generally extended from the Illinois and Black Warrior regions into the Arkansas Valley region, and the presence of Chesterian outliers high in the Ozarks indicates that at times the Ozark area was covered. Although the sea was continuous into the Ouachita region, detailed correlation of the Illinois sediments with the geosynclinal deposits of this area is difficult.

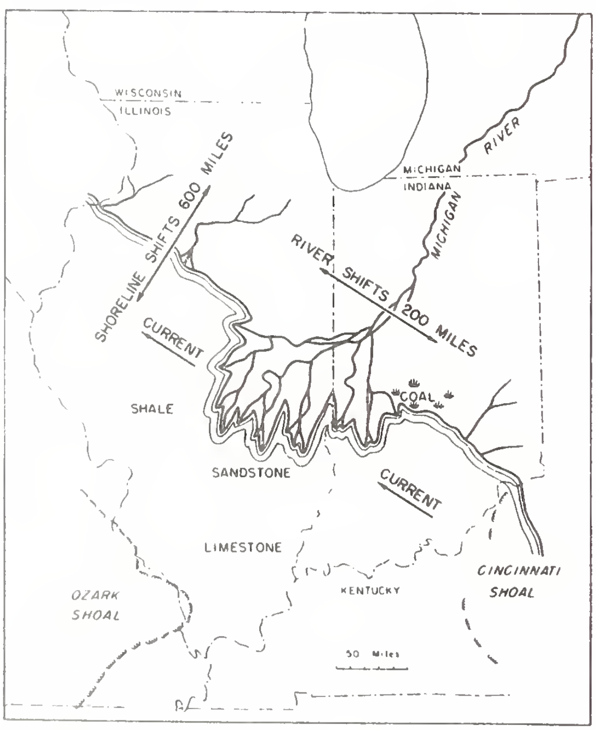
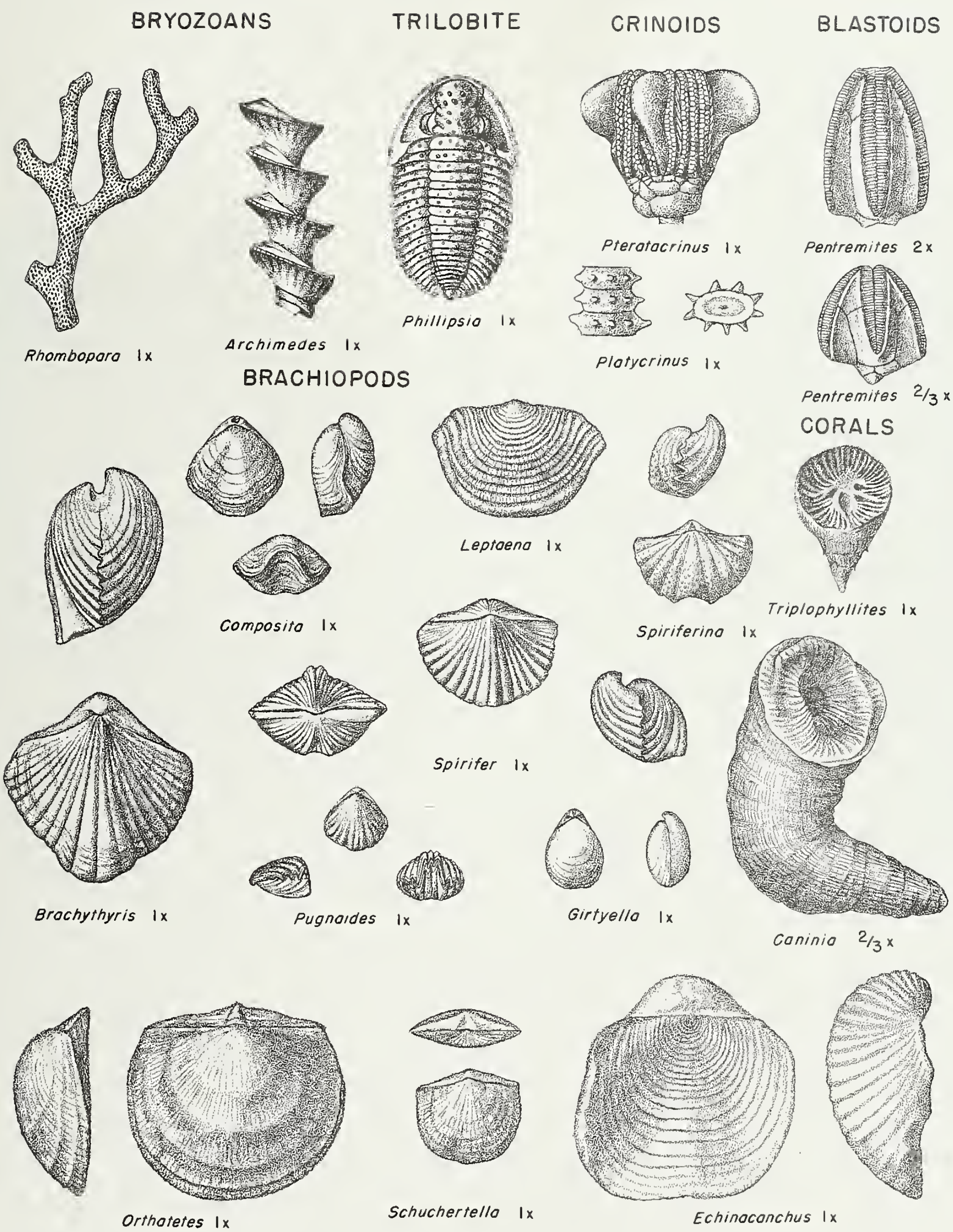


Figure 4: Paleogeography at an intermediate stage during Chesterian sedimentation.


BRYOZOANS
TRILOBITE
CRINOIDS
BLASTOIDS
Rhombopora 1x
Archimedes 1x
Phillipsia 1x
Pteratacrinus 1x
Pentremites 2x
Platycrinus 1x
Pentremites 2/3 x
BRACHIOPODS
CORALS
Leptaena 1x
Composita 1x
Triplophyllites 1x
Spiriferina 1x
Spirifer 1x
Brachythyris 1x
Pugnaides 1x
Girtyella 1x
Caninia 2/3 x
Orthatetes 1x
Schuchertella 1x
Echinacanchus 1x

LISTING OF FOSSILS FROM MISSISSIPPIAN LIMESTONES IN HARDIN AREA

	Chouteau Fm.	Burlington Fm.
Corals		
Zaphrentis tenella	X	
Zaphrentis sp.		X
Triplophyllidium dalei		X
Monilopora sp	X	
Blastoids		
Schizoblastus sayi		X
Orbitremites caleycinus		X
Crinoids		
Eutrochocrinus cf. planadicus		X
Agaricocrinus sp.		X
Platycrinus scrobinus		X
stems & plates	X	X
Bryozoans		
Fenestella	X	X
Rhombopora	X	
Cystodictya lineata		X
Cystodictya ocellata		X
Cystodictya pustulosa		X
Brachiopods		
Orbiculoidea sampsoni	X	
Leptaena analoga	X	
Leptaena sp.	X	
Chonetes glenparkensis	X	
Chonetes illinoisensis		X
Avonia concentrica	X	
Productella sp.	X	
Avonia blairi	X	
Avonia cf. indianensis	X	
Rhipidomella tenuicosta	X	
Rhipidomella sp.	X	
Schizophoria chouteauensis		X
Schizophoria swallowi		X
Camarotoechia chouteauensis	X	
Camarotoechia sp.	X	
Shumardella missouriensis	X	
Shumardella sp.	X	
Dielasma osceolense		X
Dielasma sp.	X	
Spiriferina subtexta	X	
Spiriferina sp.	X	
Spirifer forbesi		X
Spirifer gregeri		X
Spirifer grimesi		X
Spirifer keokuk		X
Spirifer louisianensis	X	
Spirifer mundulus	X	X

Brachythyris chouteauensis	X	X
Brachythyris suborbicularis		X
Syringothyris hannibalensis	X	
Syringothyris platypleurus	X	
Spiriferella latior		X
Ambocoelia parva	X	
Hustedia circularis	X	
Athyris lamellosa		X
Cleiothyridina glenparkensis	X	
Cleiothyridina obmaxima		X
Cleiothyridina sp.	X	
Bivalves (clams)		
Parallelodon cf. cochlearis	X	
Parallelodon sp.	X	
Aviculopecten sp.	X	
Pterinopectin sedaliensis	X	
Pernopecten circularis	X	
Pernopecten cooperensis	X	
Cypricardinia sulcifera	X	
Gastropods (snails)		
Pleurotomaria northviewensis	X	
Pleurotomaria subcarbonaria	X	
Cyclonema sp.	X	
Loxonema sp.	X	
Platyceras haliotoides	X	
Cephalopods		
Orthoceras chemungense	X	
Trilobites		
Griffithides portlocki		X

After Rubey 1952

PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

During the past million years or so, an interval of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. The cooling of the earth's surface, a prerequisite for glaciation, began at least 2 million years ago. On the basis of evidence found in subpolar oceans of the world (temperature-dependent fossils and oxygen-isotope ratios), a recent proposal has been made to recognize the beginning of the Pleistocene at 1.6 million years ago. Ice sheets formed in sub-arctic regions many times and spread outward until they covered the northern parts of Europe and North America. In North America, early studies of the glacial deposits led to the model that four glaciations could explain the observed distribution of glacial deposits. The deposits of a glaciation were separated from each other by the evidence of intervals of time during which soils formed on the land surface. In order of occurrence from the oldest to the youngest, they were given the names Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. Work in the last 30 years has shown that there were more than four glaciations but the actual number and correlations at this time are not known. Estimates that are gaining credibility suggest that there may have been about 14 glaciations in the last one million years. In Illinois, estimates range from 4 to 8 based on buried soils and glacial deposits. For practical purposes, the previous four glacial stage model is functional, but we now know that the older stages are complex and probably contain more than one glaciation. Until we know more, all of the older glacial deposits, including the Nebraskan and Kansan will be classified as pre-Illinoian. The limits and times of the ice movement in Illinois are illustrated in the following pages by several figures.

The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because the time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused them to flow outward at their margins, often for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Tongues of ice, called lobes, flowed southward from the Canadian centers near Hudson Bay and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch below shows several centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it has been invaded by glaciers from every center.

Effects of Glaciation

Pleistocene glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice entrenched new drainageways, deepened old ones, and then partly refilled both with sediments as great quantities of rock and earth were carried beyond the glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was enough to lower the sea level from 300 to 400 feet below present level. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments.

In most of Illinois, then, glacial and meltwater deposits buried the old rock-ribbed, low, hill-and-valley terrain and created the flatter landforms of our prairies. The mantle of soil material and the buried deposits of gravel, sand, and clay left by the glaciers over about 90 percent of the state have been of incalculable value to Illinois residents.

Glacial Deposits

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called **drift**. Drift that is ice-laid is called **till**. Water-laid drift is called **outwash**.

Till is deposited when a glacier melts and the rock material it carries is dropped. Because this sediment is not moved much by water, a till is unsorted, containing particles of different sizes and compositions. It is also stratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand and boulders is called **diamicton**. This is a term used to describe a deposit that could be interpreted as till or a mass wasting product.

Tills may be deposited as **end moraines**, the arc-shaped ridges that pile up along the glacier edges where the flowing ice is melting as fast as it moves forward. Till also may be deposited as **ground moraines**, or **till plains**, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glaciers. Northeastern Illinois has many alternating ridges and plains, which are the succession of end moraines and till plains deposited by the Wisconsinan glacier.

Sorted and stratified sediment deposited by water melting from the glacier is called **outwash**. Outwash is bedded, or layered, because the flow of water that deposited it varied in gradient, volume, velocity, and direction. As a meltwater stream washes the rock materials along, it sorts them by size—the fine sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical Pleistocene outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that look much like modern stream deposits in some places. In general, outwash tends to be coarser and less weathered, and alluvium is most often finer than medium sand and contains variable amounts of weathered material.

Outwash deposits are found not only in the area covered by the ice field but sometimes far beyond it. Meltwater streams ran off the top of the glacier, in crevices in the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed in the ice is preserved as a sinuous ridge called an **esker**. Some eskers in Illinois are made up of sandy to silty deposits and contain mass wasted diamicton material. Cone-shaped mounds of coarse outwash, called **kames**, were formed where meltwater plunged through crevasses in the ice or into ponds on the glacier.

The finest outwash sediments, the clays and silts, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the sags of the till plains, and some low, moraine-diked till plains. Meltwater streams that entered a lake rapidly lost speed and also quickly dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting and short-lived streams that laid down a broad, flat blanket of outwash that formed an **outwash plain**. Outwash was also carried away from the glacier in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and were greatly widened and deepened during times of the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as **valley trains**. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.

Loess, Eolian Sand and Soils

One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. **Loess** is the name given to windblown deposits dominated by silt. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out **eolian sand** which commonly formed **sand dunes** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principle source of sand. Flat areas between dunes are generally underlain by eolian **sheet sand** that is commonly reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand pinches out, often within one mile.

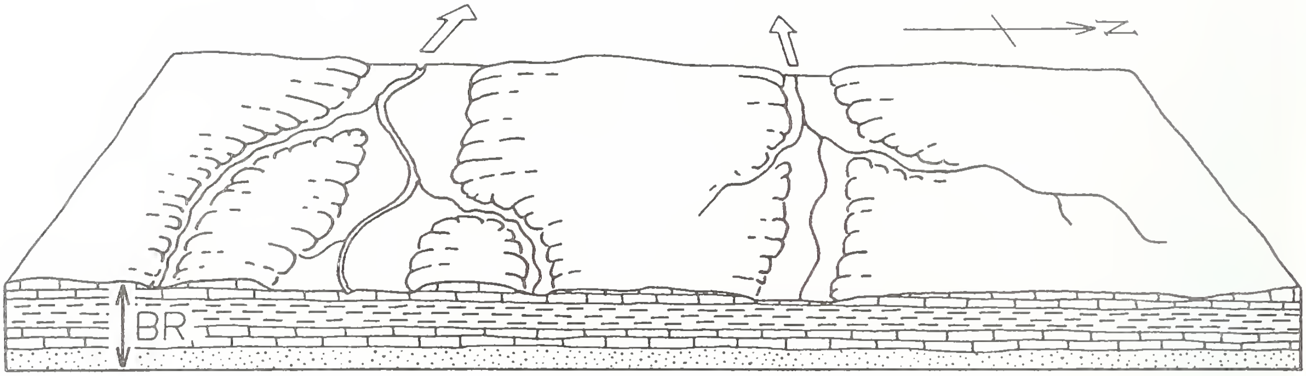
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, west winds prevailed, and the loess deposits are thickest on the east sides of the source valleys. The loess thins rapidly away from the valleys but extends over almost all the state.

Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the Pleistocene deposits and altered their composition, color, and texture. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as "key beds," or stratigraphic markers, and are evidence of the passage of a long interval of time.

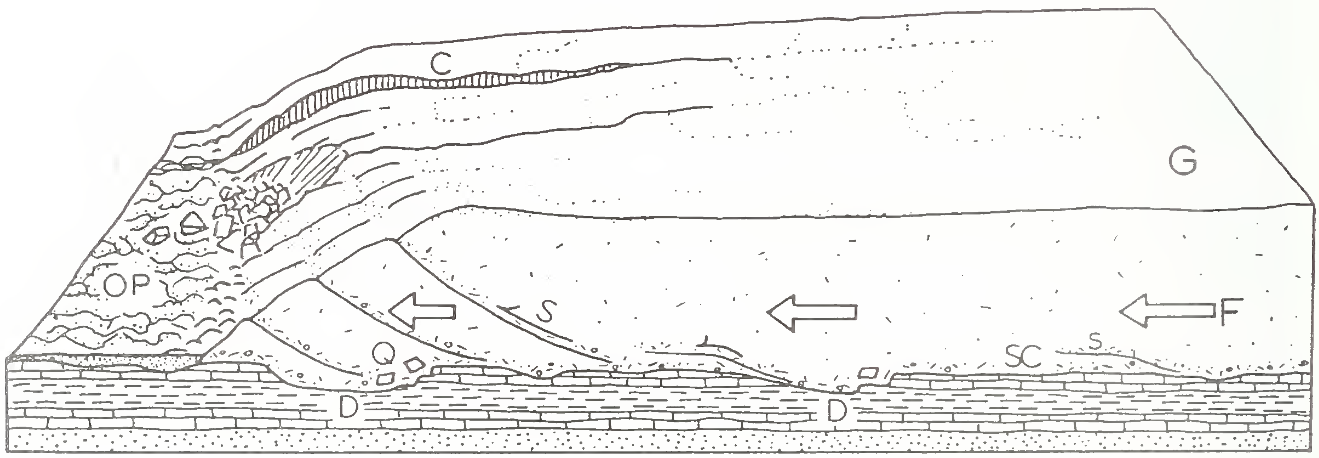
Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions and also the present-day mountain glaciers and polar ice caps.

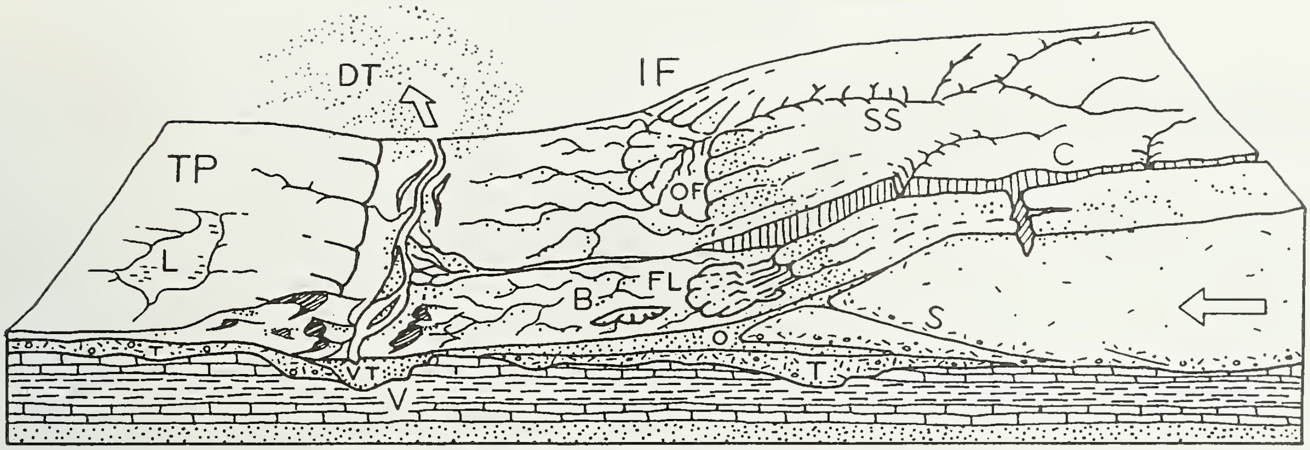
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



1. **The Region Before Glaciation** — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



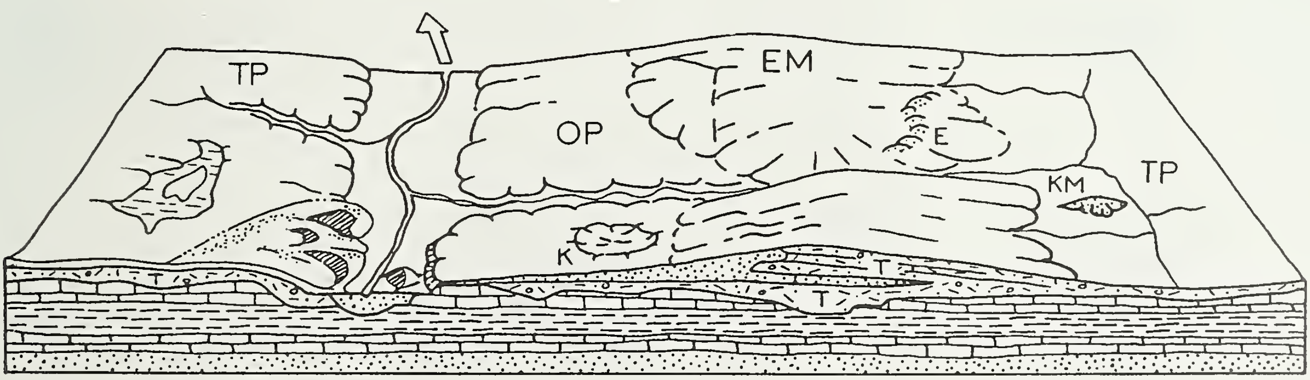
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or stop flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing mixes the load very thoroughly. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plain (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5000 or so feet thick, and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.



3. **The Glacier Deposits an End Moraine** — After the glacier advances across the area, the climate warms and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is depositing an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) remains as a till layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later, outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.



4. **The Region after Glaciation** — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream goes through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

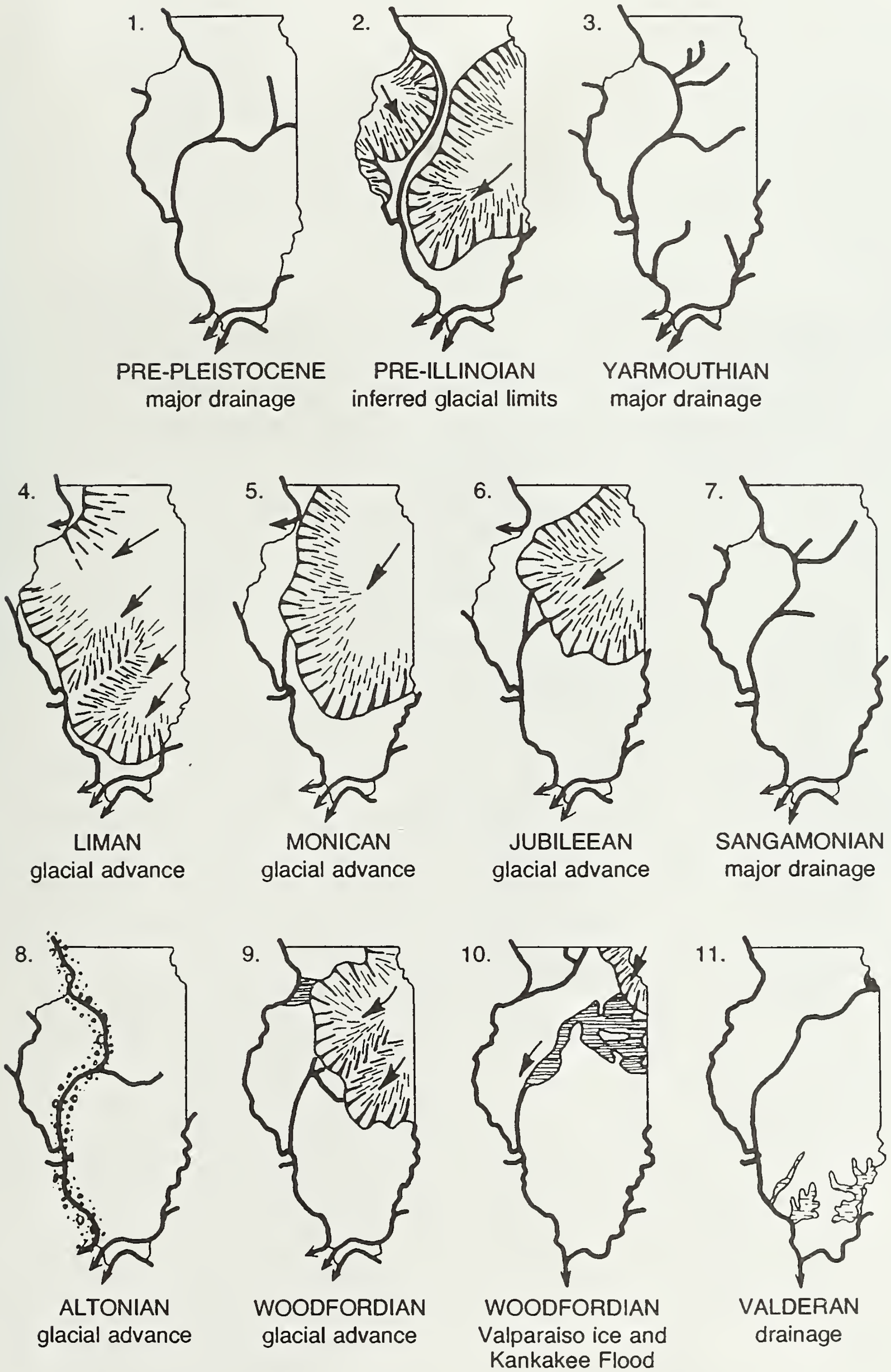
TIME TABLE OF PLEISTOCENE GLACIATION

		STAGE		SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
QUATERNARY		HOLOCENE (interglacial)		Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
				10,000		
	Pleistocene	WISCONSINAN (glacial)	late	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
				11,000		
				Twocreekan	Peat and alluvium	Ice withdrawal, erosion
				12,500		
				Woodfordian	Drift, loess, dunes, lake deposits	Glaciation; building of many moraines as far south as Shelbyville; extensive valley trains, outwash plains, and lakes
				25,000		
			mid	Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
				28,000		
			early	Altonian	Drift, loess	Glaciation in Great Lakes area, valley trains along major rivers
				75,000		
		SANGAMONIAN (interglacial)			Soil, mature profile of weathering	Important stratigraphic marker
				125,000		
		ILLINOIAN (glacial)		Jubileean	Drift, loess, outwash	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
				Monican	Drift, loess, outwash	
				Liman	Drift, loess, outwash	
				300,000?		
		YARMOUTHIAN (interglacial)			Soil, mature profile of weathering	Important stratigraphic marker
				500,000?		
	Pre-Illinoian	KANSAN* (glacial)			Drift, loess	Glaciers from northeast and northwest covered much of state
				700,000?		
		AFTONIAN* (interglacial)			Soil, mature profile of weathering	(hypothetical)
				900,000?		
		NEBRASKAN* (glacial)			Drift (little known)	Glaciers from northwest invaded western Illinois
				1,600,000 or more		

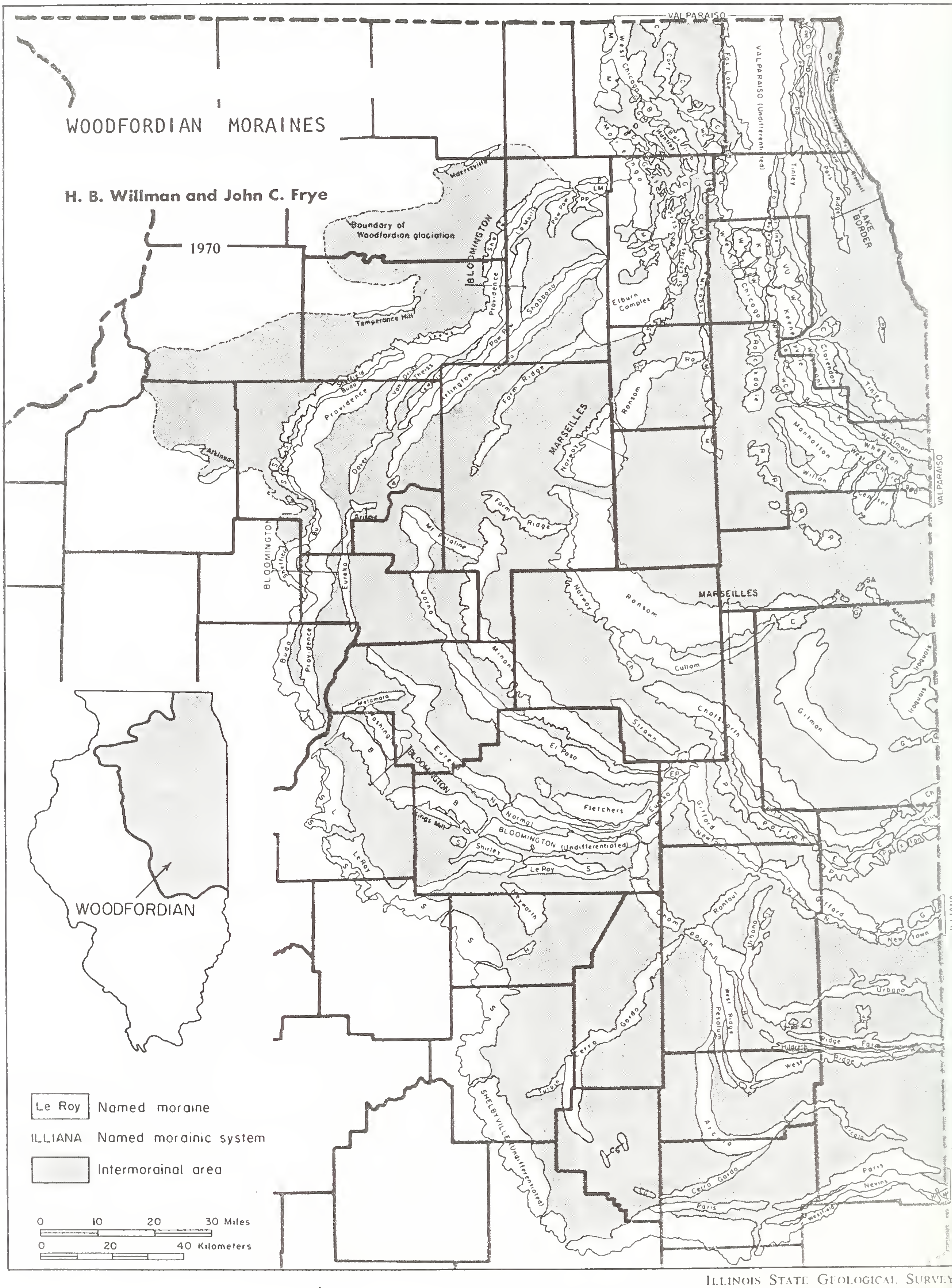
*Old oversimplified concepts, now known to represent a series of glacial cycles.

(Illinois State Geological Survey 1973

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



(Modified from Willman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)


WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
VALPARAISO
LAKE BORDER
BLOOMINGTON
MARSEILLES
ILLIANA
SHELBYVILLE
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers

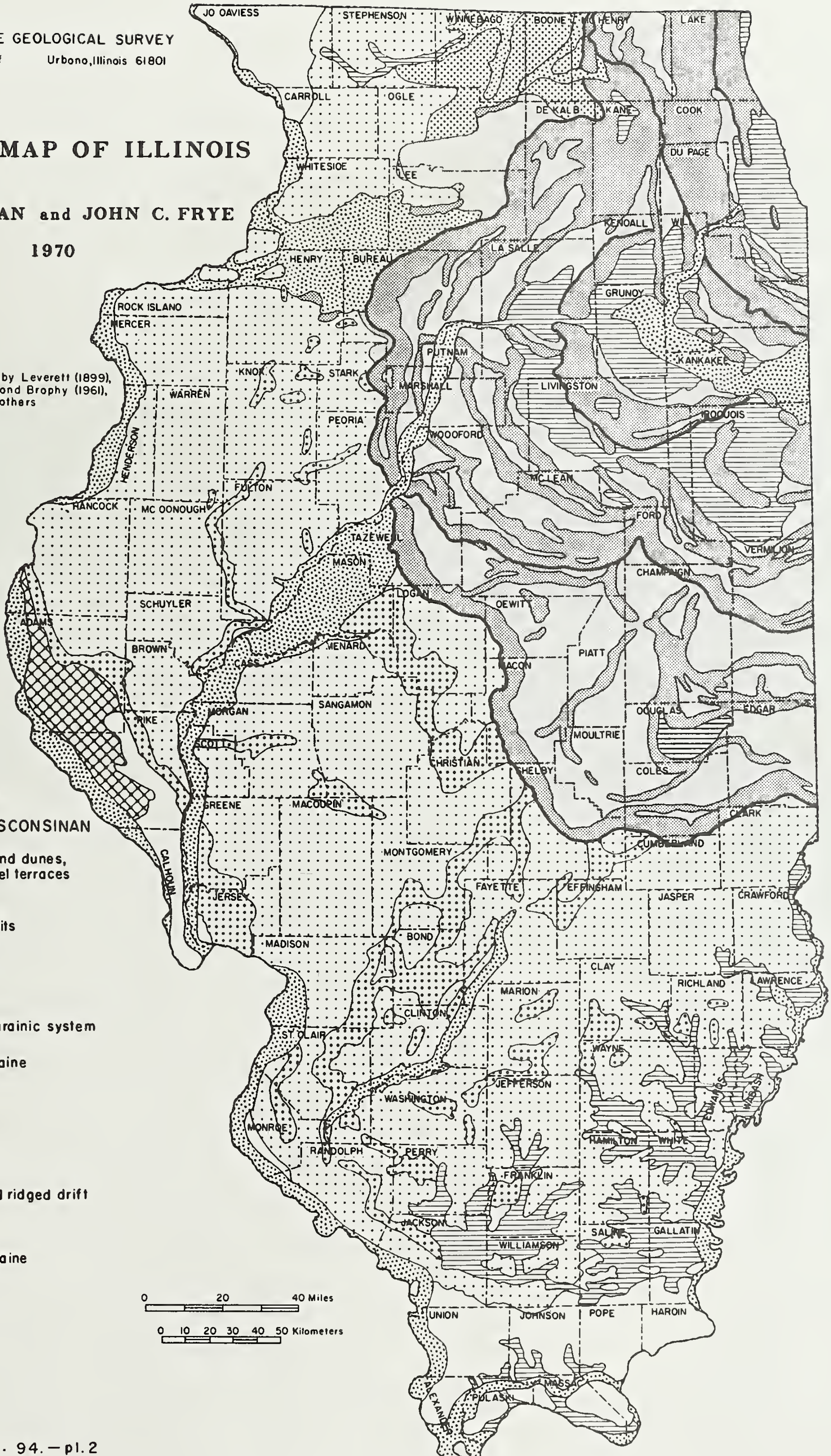
ILLINOIS STATE GEOLOGICAL SURVEY
John C. Frye, Chief Urbana, Illinois 61801

GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

Modified from maps by Leverett (1899), Ekblaw (1959), Leighton and Brophy (1961), Willman et al. (1967), and others



EXPLANATION

HOLOCENE AND WISCONSINAN

Alluvium, sand dunes, and gravel terraces

WISCONSINAN

Lake deposits

WOODFORDIAN

Moraine

Front of morainic system

Groundmoraine

ALTONIAN

Till plain

ILLINOIAN

Moraine and ridged drift

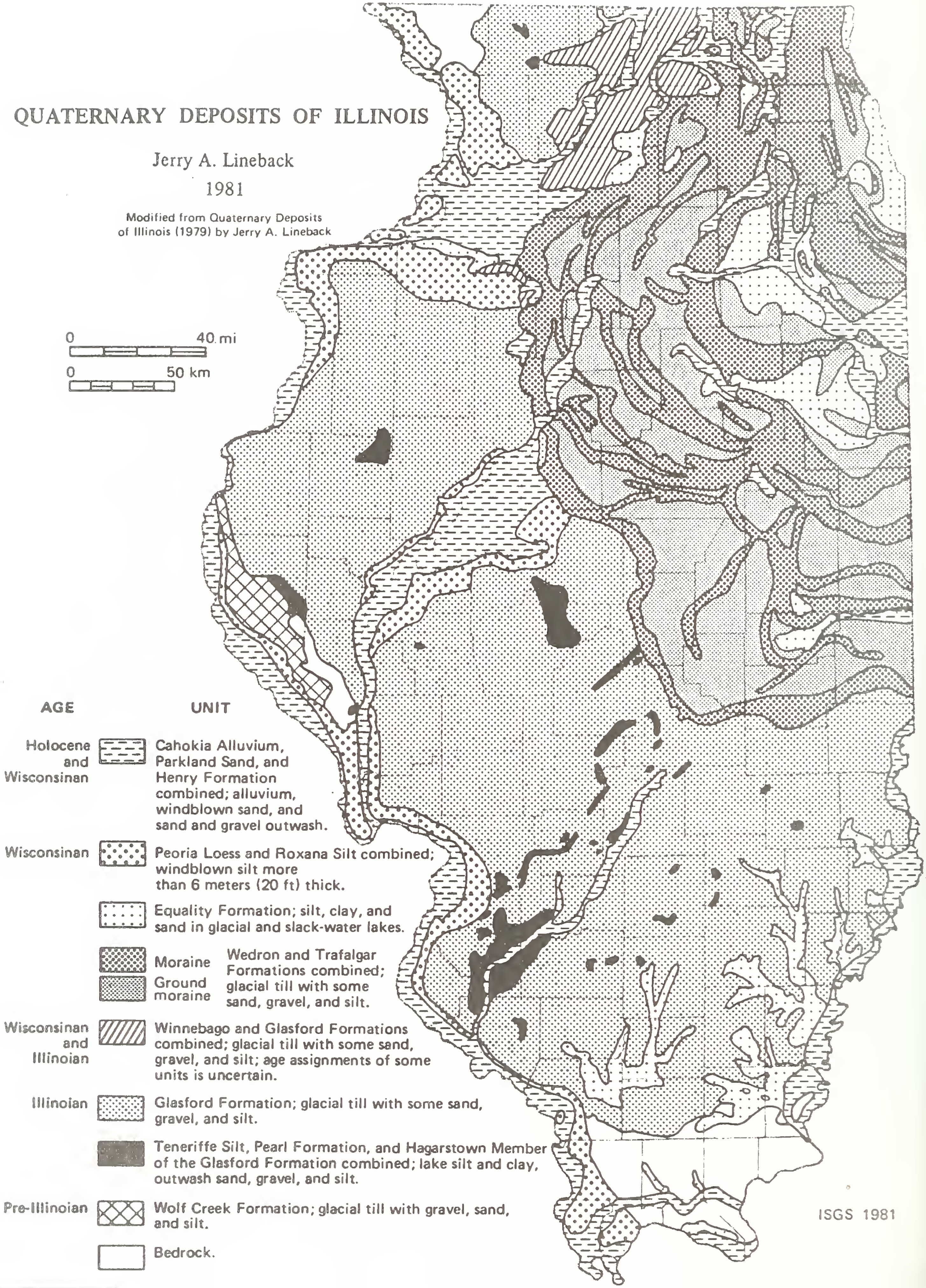
Groundmoraine

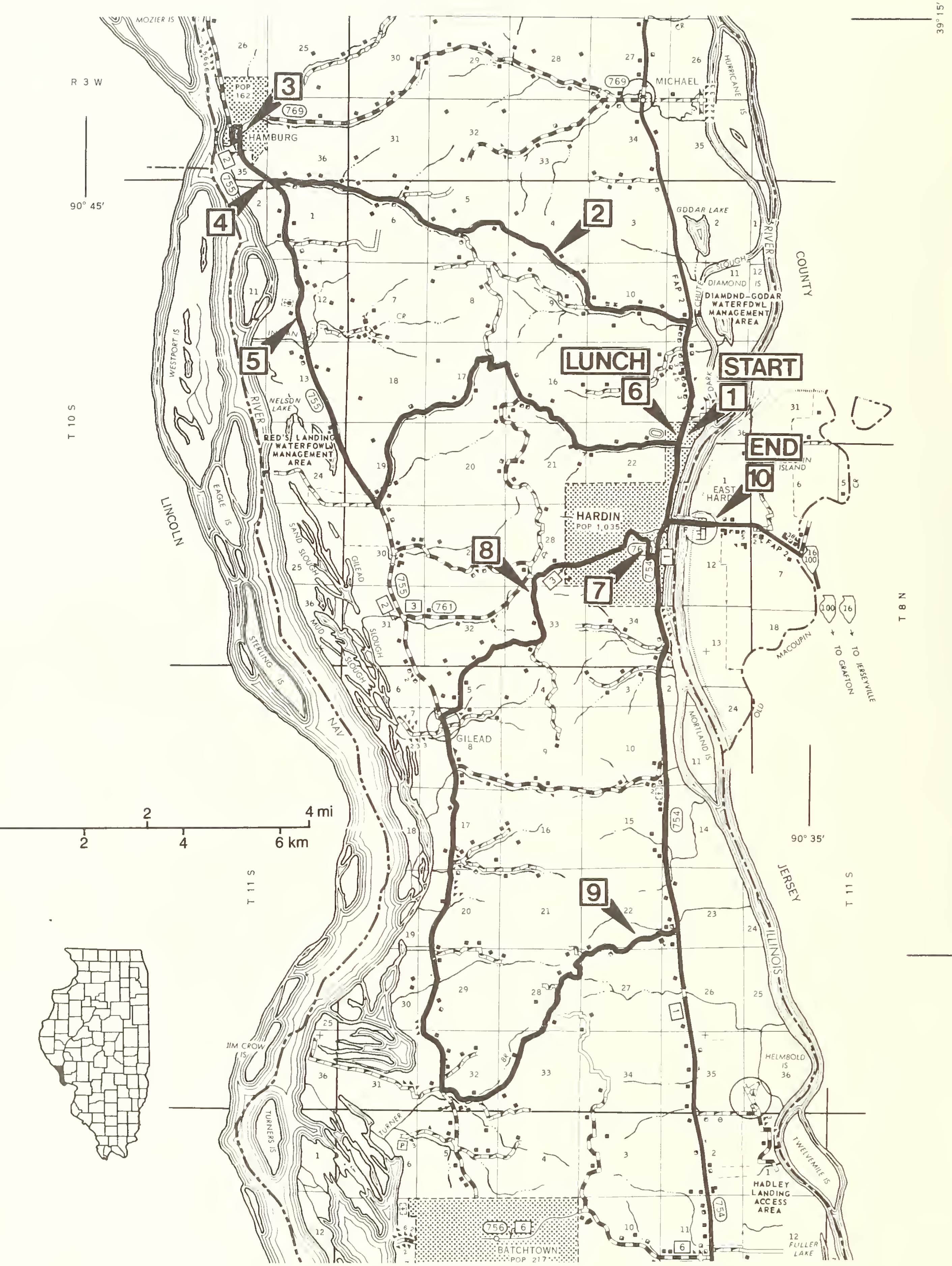
KANSAN

Till plain

DRIFTLESS

Modified from Bull. 94.—pl. 2


QUATERNARY DEPOSITS OF ILLINOIS
Jerry A. Lineback
1981
Modified from Quaternary Deposits of Illinois (1979) by Jerry A. Lineback
0 40 mi
0 50 km
AGE
UNIT
Holocene and Wisconsinan
Cahokia Alluvium, Parkland Sand, and Henry Formation combined; alluvium, windblown sand, and sand and gravel outwash.
Wisconsinan
Peoria Loess and Roxana Silt combined; windblown silt more than 6 meters (20 ft) thick.
Equality Formation; silt, clay, and sand in glacial and slack-water lakes.
Moraine
Ground moraine
Wedron and Trafalgar Formations combined; glacial till with some sand, gravel, and silt.
Wisconsinan and Illinoian
Winnebago and Glasford Formations combined; glacial till with some sand, gravel, and silt; age assignments of some units is uncertain.
Illinoian
Glasford Formation; glacial till with some sand, gravel, and silt.
Teneriffe Silt, Pearl Formation, and Hagarstown Member of the Glasford Formation combined; lake silt and clay, outwash sand, gravel, and silt.
Pre-Illinoian
Wolf Creek Formation; glacial till with gravel, sand, and silt.
Bedrock.
ISGS 1981



START
1
2
3
4
5
LUNCH
6
7
8
9
10
END
HAMBURG
POP 162
MICHAEL
HARDIN
POP 1,035
GILEAD
BATCHTOWN
POP 217
EAST HARDIN
GODDAR LAKE
DIAMOND-GODAR WATERFOWL MANAGEMENT AREA
RED'S LANDING WATERFOWL MANAGEMENT AREA
NELSON LAKE
HADLEY LANDING ACCESS AREA
FULLER LAKE
MOZIER IS
WESTPORT IS
EAGLE IS
STERLING IS
JIM CROW IS
TURNERS IS
MORTLAND IS
HELMBOLD IS
TWELVEMILE IS
HURRICANE IS
DIAMOND IS
SAND SLOUGH
MUD SLOUGH
GILEAD SLOUGH
CHUTE SLOUGH
RIVER
NAV
ILLINOIS RIVER
LINCOLN
JERSEY
COUNTY
MACOUPIN
TO GRAFTON
TO JERSEYVILLE
FAP 2
R 3 W
T 10 S
T 11 S
T 8 N
90° 45′
90° 35′
39° 15′
39° 05′
2
4 mi
2
4
6 km